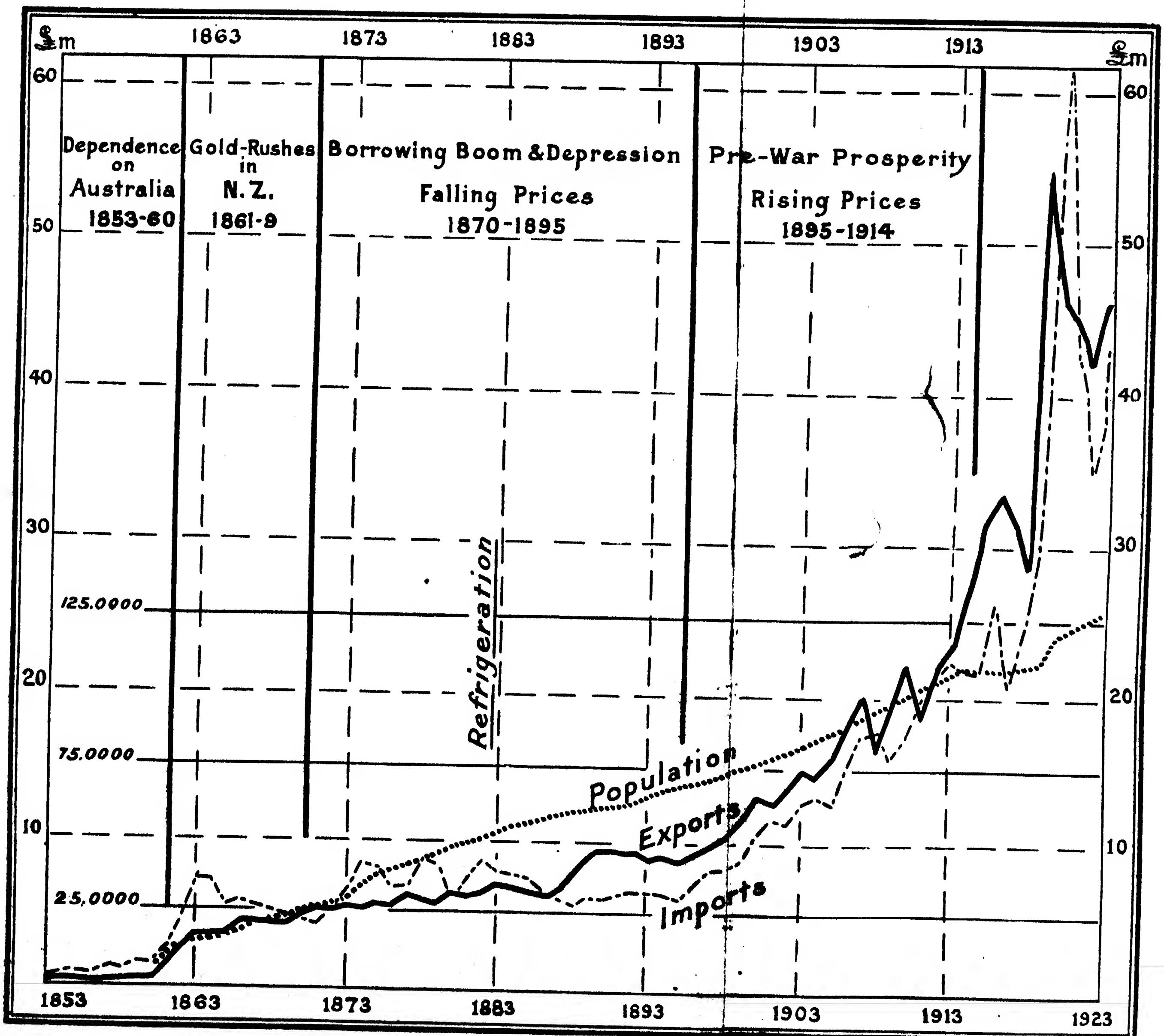
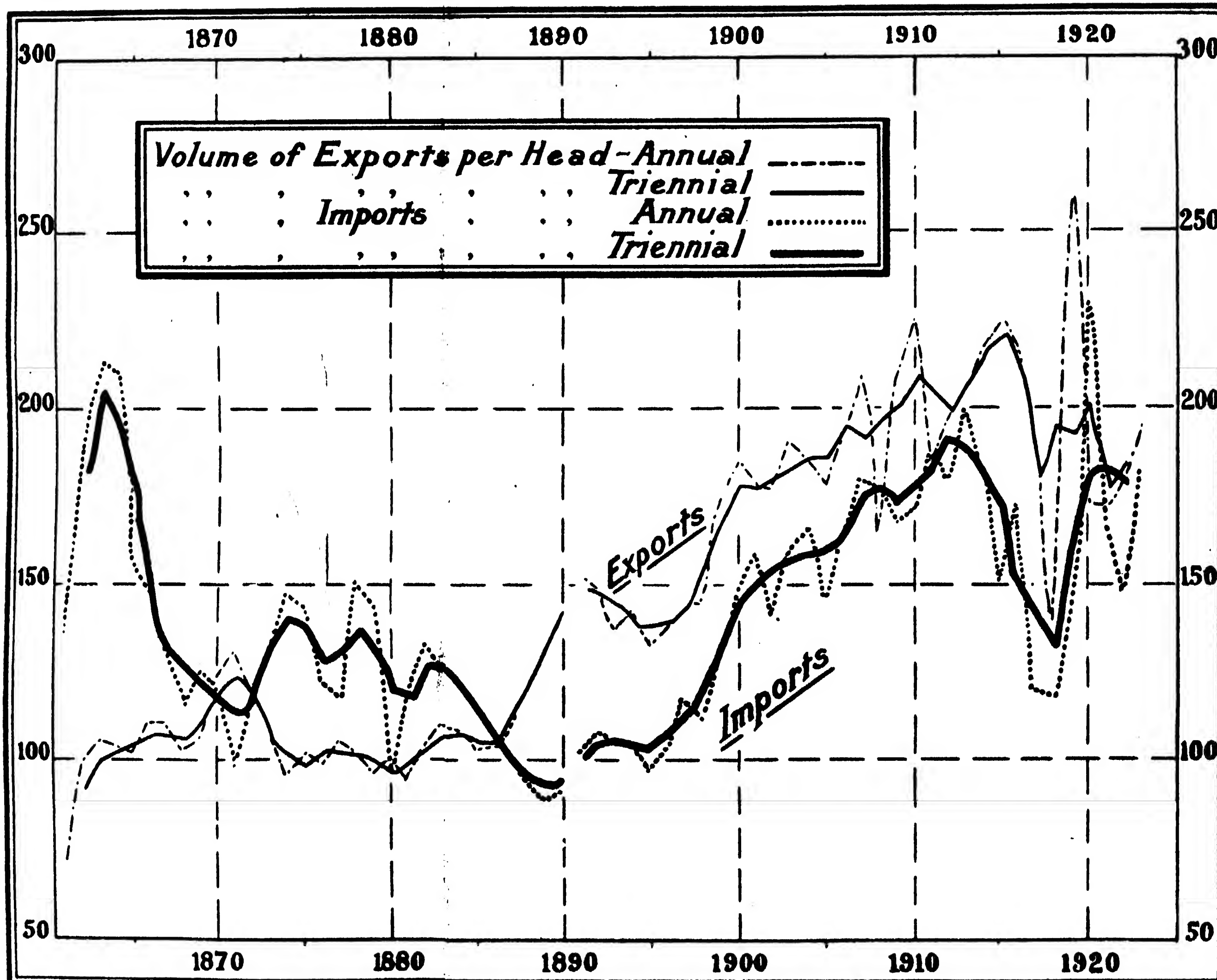


[From the *Accountants' Journal*, 20th November, 1924, p. 141.

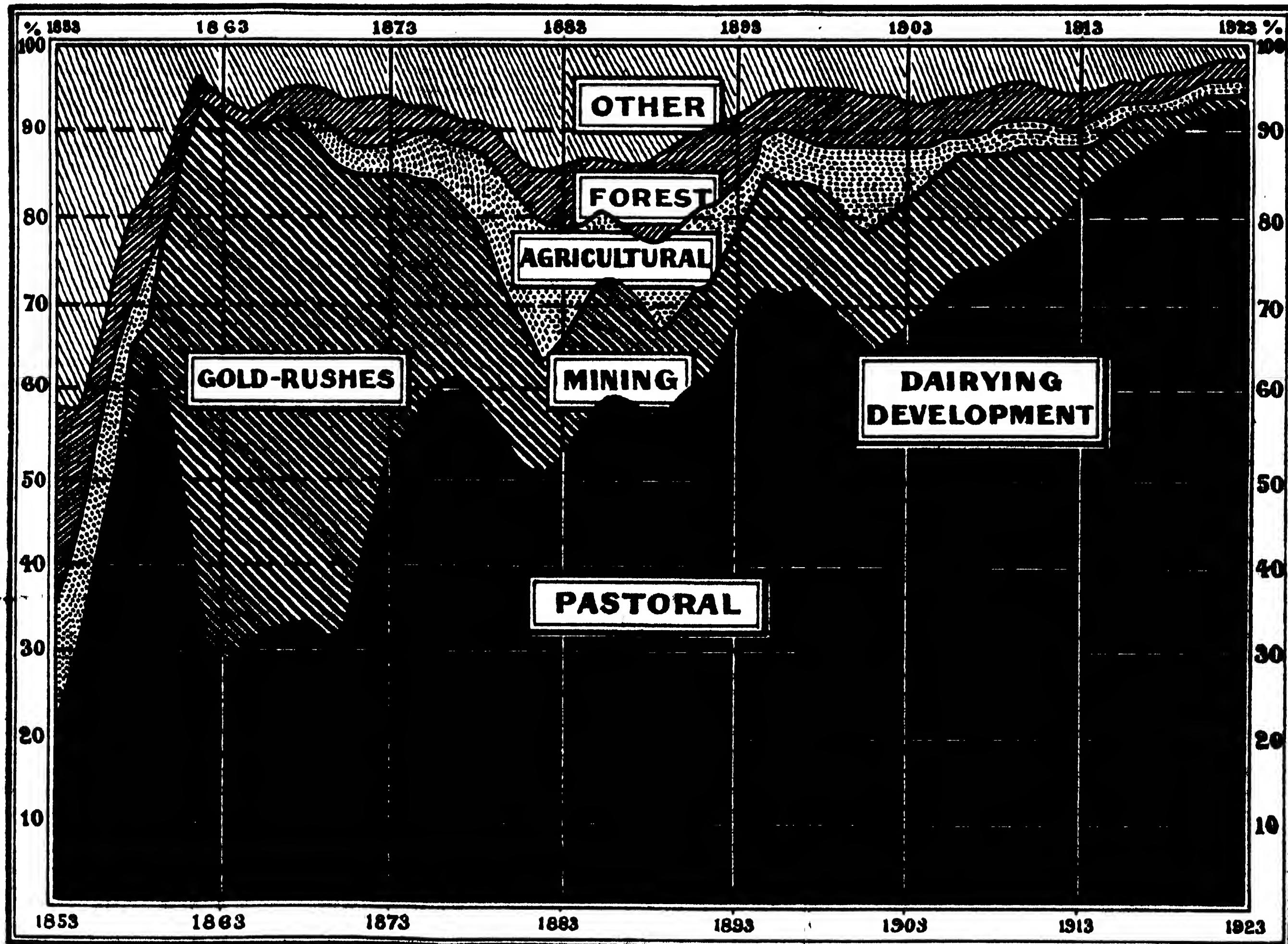
DIAGRAM A.—Annual Imports and Exports of New Zealand, 1853–1923, compared with Growth of Population.
(Statistics taken from official publications.)

Face p. 724.]



[From the *Accountants' Journal*, 20th November, 1924, p. 143.

DIAGRAM B.—Volume of New Zealand Imports and Exports per Head of Population, 1861–1933



[From the *Accountants' Journal*, 20th November, 1924, p. 145.

DIAGRAM C.—Proportions per Cent. of the Total Exports, 1853–1923, provided by the Main Industries of New Zealand.

(Statistics for years 1853–1900 built up from approximate figures in author's thesis, printed in Appendix to *N.Z. Official Year-book*, 1915; subsequent statistics from *N.Z. Official Year-book*, 1924.)

NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

THE publications of the New Zealand Institute consist of—

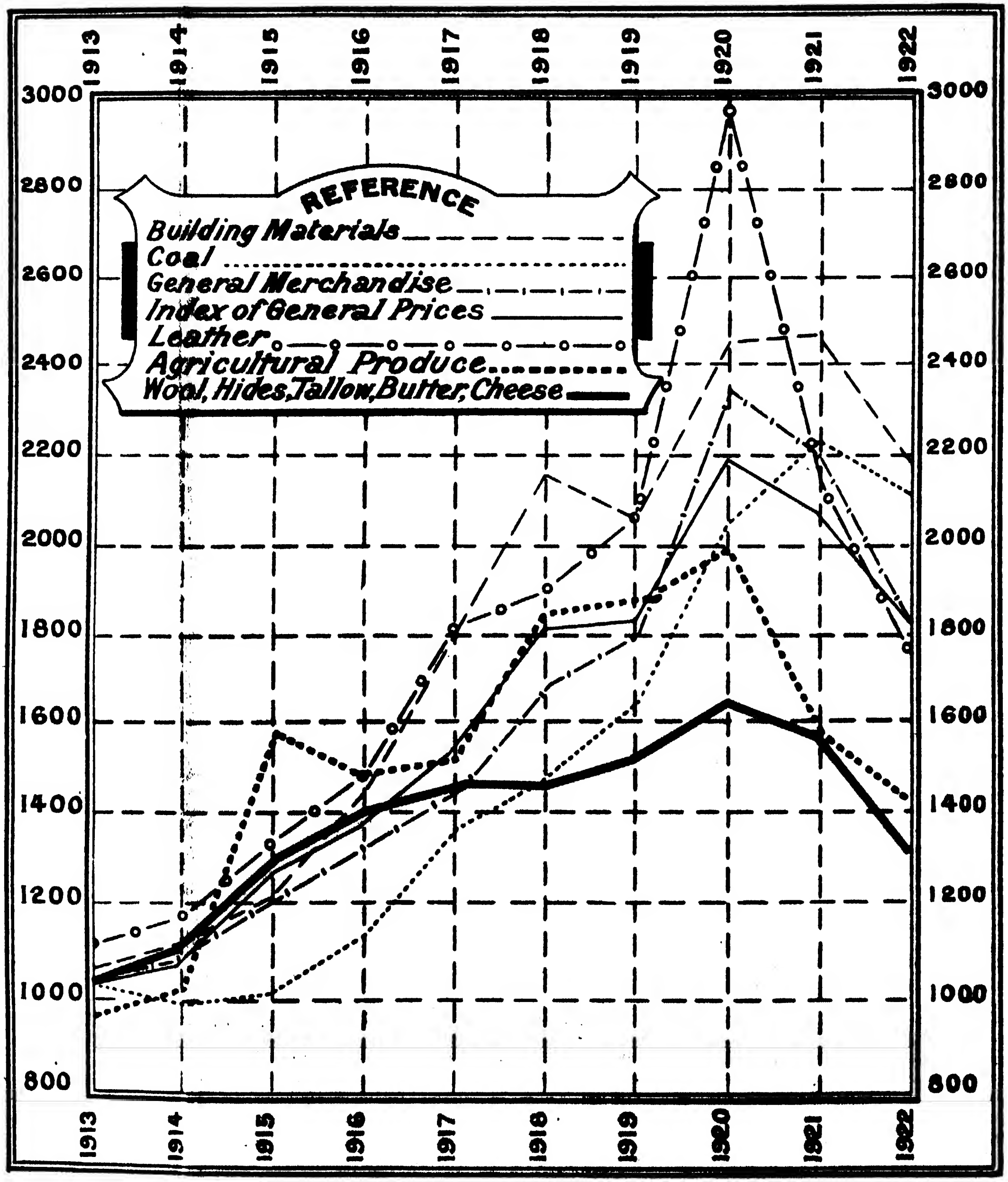
1. **Transactions,** a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.

2. **Proceedings,** containing report of the annual meeting of the Board of Governors of the New Zealand Institute, abstracts of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The *Proceedings* are of the same size as the *Transactions*, and are bound up with the yearly volume of *Transactions* supplied to members.

3. **Bulletins.** Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of the *Transactions*. The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

LIBRARY PRIVILEGES OF MEMBERS.—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute during 1924 see pp. 810–17.

ADDRESSES OF MEMBERS.—Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.



[From the *Accountants' Journal*, 20th December, 1924, p. 200.

DIAGRAM D.—Wholesale Prices in New Zealand, 1913–22.

ENTOMOLOGICAL NOMENCLATURE.

THE following paragraphs are quoted from a letter to Dr. R. J. Tillyard from the Hon. Secretary of the British National Committee on Entomological Nomenclature, 41 Queen's Gate, South Kensington, London, S.W.7 :—

"At a meeting of the British National Committee on Entomological Nomenclature held on 17th September, 1924, it was decided, following on the suggestion of one of our colonial entomologists with regard to the appointment of Corresponding Members of the British National Committee, that you should be invited to act as the Corresponding Member for New Zealand of the British National Committee.

"In view of the difficulties attendant on the formation of separate national committees in each of the colonies, owing to the small number and often isolated situation of the active taxonomists there, it is felt that the interests of colonial entomologists may perhaps best be served by the appointment in each colony of a Corresponding Member, to whom all nomenclatorial problems could be referred, and who would be able to keep in close touch with the British National Committee.

"Will you please let me know if you are willing to act in this capacity ?"

Dr. Tillyard has accepted the duties of Corresponding Member for New Zealand, and this note is made in the *Transactions* for the information of entomologists in New Zealand.

MEMORANDUM FOR AUTHORS OF PAPERS.

The attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer. It is of importance that in typewritten as well as other copy ample space should be left between the lines.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions*.

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

9. *Line Drawings.*—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth, white surface.

10. *Wash Drawings.*—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than neutral tint, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in line drawings, a fine surface should be used (the grain of most drawing-papers reproduces in the print with bad effect), and well-modelled contrasted work will give satisfactory results.

11. *Size of Drawings.*—The printed plate will not exceed 7½ in. by 4½ in., and drawings for plates may be to this size, or preferably a multiple thereof, maintaining the same proportion of height to width of plate. When a number of drawings are to appear on one plate they should be

neatly arranged, and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction In plates of wash drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding 4⅛ in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, &c., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references are best arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:—

Benham, W. B., 1915. Oligochaeta from the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 174-85.

Park, J., 1910. *The Geology of New Zealand*, Christchurch, Whitcombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, &c.—and initials of authors should be given.

14. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions*.

15. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price.

TRANSACTIONS

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 56

(NEW ISSUE)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

ISSUED 12TH JULY, 1926

Wellington, N.Z.

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DONALD PETRIE.

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OBITUARY.

DONALD PETRIE, 1846 - 1925.

The death of Donald Petrie on the 1st September, 1925, has removed from the body of New Zealand men of science an outstanding figure, and from the New Zealand Institute almost the oldest member. With his passing has also gone, so far as those publishing taxonomic matters are concerned, the last adherent in this country to the old school of taxonomic botany, a school to which science is greatly indebted, but which no longer serves the present-day needs of New Zealand botany.

Petrie was born in Morayshire, Scotland, on the 7th September, 1846. He was educated first at the Aberdeen Grammar School, and later at the University of that city, where he graduated M.A. at the age of twenty-one. Coming shortly afterwards to Victoria, he was appointed to a mastership in Scotch College, Melbourne, where he remained for six years. In 1874 he received the appointment of Inspector of Schools to the Provincial Government of Otago, and two years later, the provinces being abolished, his services were transferred to the Education Board of that provincial district, where he remained till 1894, when he became Chief Inspector for the Auckland Board of Education.

On the 17th February, 1874, he joined the Otago Institute, those of that society at that time interested in botany or zoology being Messrs. A. Bathgate, G. M. Thomson, P. Thomson, W. Martin, J. S. Webb, Dr. T. M. Hocken, Captain F. W. Hutton, Professor M. Coughtrey, and the Right Rev. Bishop Nevill. It was doubtless the influence of Mr. G. M. Thomson, who at that time was eagerly studying the plants of Otago, which turned Petrie in the direction of field botany. Hooker's *Handbook of the New Zealand Flora*, then ten years old, had been well tested by T. Kirk and others, and found to be—admirable as it was for the period it appeared, though based on dried material—a by no means reliable guide. It was clear, in fact, that much remained to be done (but how much no one then could dream) both in the matter of discovering and defining undescribed species, in gaining knowledge concerning those already described, and in finding out greatly needed details regarding their distribution. Work of the kind just indicated evidently appealed strongly to Petrie, so that he very soon commenced to prosecute it with enthusiasm, notwithstanding he had received no previous scientific training, a rather common occurrence with those whose names count high in research.

In those days, and for many years afterwards, School Inspectors either rode or drove through their districts; they would also frequently be away from home at the week-end. Petrie took every advantage of this state of affairs. In his buggy was always his collecting-press—two small, thin mahogany boards, about 12 in. by 9 in., with a considerable thickness of botanical drying-paper between them; his keen eyes scanned the vegetation on the roadside as he drove leisurely along, and but little would escape his vision. Week-ends and holidays he made special excursions, and many high mountains were ascended, most of them botanically unexplored or, at best, superfically examined previously. Mounts Ida, Pisa, and Cardrona, the Old Man Range, the Rock and Pillar, the Dunstan and Hector Mountains are names which always bring Petrie to my mind's eye.

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* He always used presses of this kind and size. Of course, they greatly limit the dimensions of specimens, but, on the other hand, they are light, easy to use, even in a high wind, and the small papers can be readily dried.

This search for plants was no mere hobby, to be taken up for a time and then dropped, but it developed into the serious business of life, ceasing only for about a year before his lamented death. In short, for some fifty years Petrie carried on this essential preliminary work, so that there is not one of the botanical districts of the main Islands of New Zealand where his footsteps cannot be traced; indeed, he was fairly familiar with the distribution of the flora from the north of Auckland to the south of Stewart Island; and the results of his many excursions—long or short—are stored, well preserved and accurately labelled, in his splendid herbarium—the supreme work of his life.

Besides being a skilled collector, an accurate observer, and the patient maker of an herbarium, Petrie contributed some sixty papers to the *Transactions of the New Zealand Institute* and other journals. The greater part are descriptions of unknown plants—in all about 180 species or varieties. Two papers stand out as of special value—the one a list of all the species of spermophytes of Otago, and the other dealing with the flora of Stewart Island, which was almost unknown until he and G. M. Thomson made a special excursion thereto in a cutter they hired for the purpose.

In the former of the above two papers a list is given of all the species, together with details regarding their distribution, in Otago. Within the last few years it has been my good fortune to follow in Petrie's footsteps, so to speak, in Central Otago, ascending many of those mountains whose florulas he made his own, yet not one plant have I found which he had not previously seen or recorded. This speaks volumes for his thoroughness. And those who, like myself, have been with him in the field in his prime must have been amazed at his eye for plants, an eye which missed none. During one long summer's day on Kelly's Hill, Westland, I well remember he looked neither to right nor left, but steadily gazed at the carpet of plants hour by hour, pausing only to collect those which were new to him or which he wished to examine; and this was my daily experience during a rather extensive excursion he and I made about thirty-one years ago.

The Stewart Island investigation was confined to the areas—mostly low-lying—in the neighbourhood of Paterson Inlet and Port Pegasus, but from the head of the former beautiful lake-like arm of the sea the explorers managed to negotiate the swampy ground leading to Mason Bay. No less than 201 species were collected or noted, a remarkable record for a comparatively small area, the country difficult to traverse, and the time at their disposal severely limited. Various important facts were made known, especially the discovery of the Australian genera *Liparophyllum* and *Actinotus*, the occurrence of certain alpine plants at sea-level, and the virtual absence of grassland, this being represented by Cyperaceae and Restionaceae. Certainly, in this expedition G. M. Thomson played a notable part, and Petrie suitably emphasized this in *Microlaena Thomsoni*—a small grass of unusual form, now known to extend to north-west Nelson.

Had Petrie been asked what was the main result or chief object of his botanical work, he would have unhesitatating replied that it was the putting-together of an herbarium which would represent all that was known taxonomically regarding the species of New Zealand vascular plants (for with their ecology or other matters he had no concern) and their distribution. To this end, his explorations, his correspondence, and, in fact, all his botanical energies, were devoted. And so far as his conception of an herbarium went—and unfortunately it is the usual conception—he succeeded to the full. Not only is his own painstaking work of some fifty years represented, but he enlisted the assistance of pretty well every one who

has collected, or collects, New Zealand plants, from his colleagues of the early "seventies"—T. Kirk, T. F. Cheeseman, J. Buchanan, G. M. Thomson—to the youngest men of to-day. This herbarium, second only in size to that of Cheeseman, if it be not the equal, he presented a year or two ago to the Dominion Museum, Wellington, the only condition attached to the splendid gift being that it must be housed in a fireproof building. Up almost to the very last he was engaged in seeing that it was correctly labelled and put into perfect order.

To have such a great and important collection in a situation so central as Wellington is a matter of inestimable value for New Zealand botany. It contains the "types" of all the species, &c., described by Petrie, as also nearly all those of T. Kirk and T. F. Cheeseman. Further, the herbarium has been labelled in exact agreement with the new edition of Cheeseman's *Manual*, in nearly all cases from determinations made by Cheeseman himself. All that is lacking in the way of "types" are those which are present only at Kew and in other European herbaria, and a few of species described by New Zealand authors other than those mentioned above. Once the herbarium is available, all we interested in New Zealand botanical taxonomy will wonder how we got along for so many years without such a collection for reference.

As a taxonomic botanist—and taxonomy was almost his sole interest—Petrie, though theoretically a "lumper," was in practice a most confirmed "splitter," to use expressive terms now fast passing into oblivion. Thus many of his species are separated from their next-of-kin by very small distinctions. But the constancy of such differences was never established by breeding experiments, and rarely by those exact field observations which may supply strong evidence. As with the school to which he belonged—and this school contains the greatest names in taxonomic botany—Petrie considered that a species told its own tale: that a comparison between forms of close resemblance was sufficient, and that experiment was unnecessary. Thus he described, at times, species of polymorphic genera from very little material, or even from material taken from one cultivated plant. One who knows intimately *Hebe* or *Celmisia*, for instance, must feel great doubt regarding species of those genera based on such material. But this is a small matter; most of Petrie's species have proved to be beyond reproach.

This love of working with groups distinguished by small differences appealed to Petrie from the very first, when he chose for study certain critical genera of Cyperaceae, especially *Uncinia* and *Carex*, and Gramineae as a whole, and he was so successful both in discovering species—some very small—and in pointing out neglected distinctions, that he shed a flood of light on these difficult plants, and eventually became the leading authority on the grasses of this botanical region.

Petrie's researches did not extend into those branches of the science of interest to botanists in general. He was essentially a local specialist. But his work was fully recognized as of great value in the Dominion, and various New Zealand honours not easy to attain fell to his lot. Thus, he was elected President of the New Zealand Institute in 1915; in 1919 he was made one of the twenty original Fellows of the Institute; and last year he was awarded the Hector Memorial Medal and Prize. He therefore received nearly all the scientific honours which his adopted and beloved country could bestow. To this country he, on his part, gave of his very best. His loss will be felt for many years to come, and his name will always be revered as that of one of the great pioneers at a time when such were urgently needed in the domain of New Zealand field botany.

L. Cockayne.

Obituary.

ROBERT MURDOCH, 1861-1923.

ROBERT MURDOCH was born at Wangaratta, in Victoria, on the 3rd February, 1861. He received a secondary-school education, and afterwards travelled widely with Captain Shuttleworth, of Wanganui. He spent some years subsequent to 1888 in farming near Wanganui, but in 1892 he went to Sydney and studied Mollusca with Mr. Charles Hedley. Soon afterwards he entered commercial life, which he followed until his death, on the 11th November, 1923.

For many years he gave all his spare time to the study of New Zealand Mollusca. He was several times a contributor to our *Transactions* and to the *Journal of the Malacological Society*. At the time of his sudden and unexpected death he had arranged to give up business life and devote himself to research. During a visit to England about 1914 his important and extensive collections, which included several types of New Zealand Mollusca, were destroyed by fire. He was unmarried, and was well known as a prominent Freemason.

Bob Murdoch's kindly and sympathetic nature gained for him a multitude of friends throughout the country. Simple and straight in character, he had the kindliest of hearts, and was unswerving in his friendship. Scientific life in New Zealand, and particularly in Wanganui, has lost one of its most lovable leaders.

P. MARSHALL.

ROBERT MURDOCH.

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APPENDIX.

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PRESIDENTIAL ADDRESS.

The following is the presidential address delivered before the New Zealand Institute on the 17th January, 1925, by Dr. P. Marshall:—

It is generally recognized that the address of the President at our annual meeting is most fittingly devoted to considerations concerning the status of the Institute in the world of science, and to those conditions that most particularly affect its work and welfare.

At each annual meeting for the last few years we have had to lament the death during the preceding twelve months of men who have been prominent in the work of the Institute itself or of its affiliated societies. The past year has been no exception; and the names of Captain G. Mair, Dr. A. K. Newman, L. Birks, and C. M. Louisson will in future not be found in our lists of members.

In 1871 Captain G. Mair's name makes its first appearance, and from time to time thereafter he contributed papers to our annual volume of *Transactions*. A careful student of Maori life, and an ardent collector, he made thorough use of his opportunities, to the great benefit of the Auckland Museum.

Dr. A. K. Newman also became a member of the Institute in the "seventies," and has contributed articles to our *Transactions* on several occasions. Though in later years his main study dealt with Maori life, he took a great interest in astronomy, and at the last meeting of the Governors of the New Zealand Institute he was a member of a deputation which approached the Institute on the subject of the Carter bequest.

The untimely death of Mr. L. Birks is deplored by all. Though not long resident in the Dominion, he had taken an active part in the doings of the Wellington Philosophical Institute.

Dr. Fulton was a keen naturalist who was particularly interested in our native birds. He was a strong supporter of the Otago Institute, of which he was President in 1918.

The most notable scientific work of the year in New Zealand has undoubtedly been the expedition to the Chatham Islands organized by the Otago Institute. We eagerly await the publication of the observations made and of descriptions of the collections that were obtained.

All members of the Board of Governors are, of course, aware that the Institute, so far at least as its present constitution is concerned, was founded in November, 1867. In May, 1869, the first volume of the *Transactions* appeared, and from that date until some interruption during the upheaval due to the great war an annual volume has regularly been issued. The series of fifty-five volumes constitutes a record of scientific and intellectual activity of which we may well feel proud.

During the Great War enrolment of soldiers reduced the personnel of the Government Printing Office, and the occurrence of extra parliamentary sessions prevented the Printing Office from performing much work that was not connected with purely official publications. In addition, the issue of volume 16 of the *Transactions of the Australasian Association for the Advancement of Science* rightly had priority before our *Transactions* in

publication, and still further delayed the appearance of our annual volume. The accumulation of delays due to such causes was so serious that the articles which were accepted for printing could not be published at the expected date.

For these reasons the issue of the volume of *Transactions* became seriously irregular. The return to conditions which are more nearly normal during the present year has, I am glad to say, enabled our Editor, who has been most energetic and unsparing of himself, to make up for time which under the circumstances was unavoidably lost.

As a result the papers and proceedings which should have been published in 1922 did not appear until December, 1923. The articles which were accepted for publication in 1922 and 1923 were published in a single volume—No. 55 of our series—as directed by the Board of Governors, in September, 1924.

Now that the ground has been cleared and all arrears have been published, we have every reason to think that the next volume will appear on the due date. While this is satisfactory and reflects great credit on our Editor, another aspect of the matter is by no means a subject of congratulation.

The charges for printing and issue are constantly mounting up, and the total reached its highest point in the publication of the last volume. The situation that has arisen is one that must receive the earnest consideration of the Board of Governors.

The heavy strain that the issue of our annual volume has exerted on the finances of the Institute for several years past has more than once been the subject of urgent remark by gentlemen who have previously occupied the presidential chair, but the position has now become so acute that it seems that the Board of Governors will have to take some decided action.

If you turn to the table of receipts and expenditure you will find that the ordinary revenue amounts to only £1,325, while the ordinary expenditure is £1,882, if we exclude on both sides sums connected with research grants and trust funds, which, of course, cannot be appropriated for the ordinary purposes of the Institute. It is obvious that if we wish to maintain the high scientific status of the Institute as gauged by the quality of our volume of *Transactions* we must find means to increase our revenue or we must decrease our expenditure.

Our revenue at present, as the Governors are aware, is derived from a Government grant, a levy on members, and by the sale of publications. Whether an increase in any of these sources of revenue can be hoped for is a matter that should be most carefully considered.

Our expenditure is incurred in the printing of the *Transactions*, the salary of the Assistant Secretary and Librarian, the travelling-expenses of the Governors, with incidentals amounting to about £20. It is clear that at the present time the cost of printing alone is considerably more than our revenue, and unless this is reduced we cannot possibly pay our way. Those who know the amount and nature of the work of the Assistant Secretary and Librarian are doubtless aware that increase rather than decrease under this head is most reasonable. The other items of expenditure are comparatively insignificant.

The cost of printing has increased enormously of recent years. I find that the first volume, printed in 1869, cost 14s. 2d. per page. In the twenty-second volume, 1889, each page cost 9s. 5d. The cost was only

8s. 10d. for the thirty-seventh volume in 1904. It was not until 1916 that the cost rose to £1 for each page. The greatest cost was in 1920, when it rose to £2 2s. The cost for the last volume was greater than for that which preceded it, and amounted to £1 14s. 6d. It has often been suggested that the expense of printing could be reduced if the work were entrusted to a private firm. Hitherto the Governors have always taken the view that, even if the apparent cost were less, the extra labour of the Editor, and the cost of reading, revision, and corrections, would be so great as to overwhelm the apparent benefit.

The only other way in which the cost could be reduced is apparently by a reduction of the size of the volume. Such a suggestion, when viewed in the light of the interests of scientific research in New Zealand and of the intrinsic importance of the researches themselves, is to my mind unthinkable. You are aware that the Publication Committee exercises a considerable amount of discretion in regard to the material sent up from affiliated Societies and Institutes for publication, and it would be unwise, in my opinion, to be more stringent than at present in the selection of papers.

At the present juncture I think that it is not out of place to refer to the prominent, and in fact dominant, part that the New Zealand Institute has taken for fifty-six years in fostering the development of scientific activity and thought in the interest of the whole Dominion. It has placed the result of the researches in New Zealand before the world at large, to the great advantage of the country from material as well as scientific aspects.

It is well known that when a worker in the domain of science in any part of the world wishes to obtain information in regard to any bearing of his research on New Zealand he turns at once to the *Transactions of the New Zealand Institute*. It is safe to say that thousands of scientific inquirers in many countries have obtained all their knowledge of New Zealand and of its scientific interests from the pages of our volumes. A series of our *Transactions* is to be found on the shelves of important scientific libraries everywhere, and this fact more than any other has given our country a recognized place in the world of study and knowledge.

Scientific workers in New Zealand are placed in a position of considerable disadvantage. There is always a great deal of difficulty here in obtaining access to the records of scientific research and progress elsewhere, and without these a person who undertakes research is often groping blindfold. Here again our Institute is of valuable assistance, for in our library are to be found series of scientific journals of great variety which are received in exchange for our own publications from learned societies in nearly all countries. In many cases the results of scientific research in New Zealand would be almost nugatory without the assistance obtained from this library. Maintenance of our annual volume up to its present standard is necessary in order that we may continue to obtain these exchanges which are essential for research work.

Another necessity for the aspiring and energetic man of science is an organ in which his work may be published and circulated. Here the New Zealand Institute has achieved its most noteworthy claim to recognition on the part of all patriotic citizens. There are many scientific men in this country whose reputation is world-wide in their own specialty, but whose work would have remained unknown, or would have been stunted if it had ever found expression, without the opportunities that the Institute has afforded.

Professor W. J. Parker, when lecturing in Dunedin in 1892, remarked that at that time the New Zealand University was not a university in the proper sense of the word because it had not then produced a single graduate who had ventured on the publication of research work. It is noteworthy that the University has not yet been able to provide for the publication of the research work of its honours graduates, which in Professor Parker's opinion was the one line of activity in which they could win full academic status for their University.

The opportunities that the University has been unable to provide have been afforded by the New Zealand Institute, with the result that it has in large measure completed the construction of the intellectual edifice built up by the Senate of the New Zealand University, and has thereby relieved that body of a large annual expenditure. To what extent this has taken place is probably but little realized, but some estimate can be made from the indexes of the *Transactions* that have been published. For the first twenty years of publication of the *Transactions* the University had, of course, produced few matured students, and an output of researches by them could hardly be expected. For that period not more than 1 per cent. of our published articles could be credited to them. In the second period of twenty years the proportion is 35 per cent. For the succeeding period of ten years—from 1909 to 1919—65 per cent. of the articles were written by graduates of the University and other people of New Zealand birth. In the last five years the percentage has risen to 73.

This stimulation of intellectual research and provision for its expression must be regarded as a national work of the highest value. Still greater, however, is its importance for the individual. Some New Zealand men who began their career by publishing in our *Transactions* have risen to fame and eminence, and several who have hardly published anything outside them are now recognized authorities in all parts of the world in their subjects of research. We can point without difficulty to men of New Zealand birth who by virtue of the work they have published in our *Transactions* have now established themselves as authors whose work must be consulted by all who write comprehensive treatises on parasitic fungi, development of ferns, seaweeds, anatomy of flowering-plants, petrology, geomorphology, volcanic action, mollusca, crustacea, soils, ethnology—to name only a few of those important subjects in which valuable study has been done and a wide reputation gained. It is true that chemical and physical researches are less represented, partly because journals specially devoted to those subjects with a more frequent issue are preferred by authors as channels for publication.

It is safe to say that some of those who have achieved extended and high fame in their subject would have languished and remained unknown, and perhaps unproductive, but for the opportunities that have been afforded to them by the New Zealand Institute. To one who has been constantly engaged in scientific research since 1890, it gives me the most intense satisfaction to contemplate the extent to which New Zealand students, by painstaking and ardent research, have triumphed over their difficulties, and through the medium of the New Zealand Institute have acquired a recognized position of fame in the particular subject in which they have undertaken research.

My own personal experience makes me feel a special debt of gratitude, for I found that researches published in New Zealand gained for me a cordial reception at the hands of scientific men in Europe. At the British

Museum and at Jermyn Street every possible facility was given me to study and utilize all the collections and literature at the disposal of those great institutions.

Afterwards, when I attended the International Congress of Geologists at Brussels, at which thirty-eight nations were represented, I found that all those with whom I spoke had derived nearly all their knowledge of New Zealand from the papers of our *Transactions*. As showing the recognition of the high standing of science in Europe, it is interesting to record that all national delegates were individually presented to the King of Belgium, who, when speaking to the New Zealand delegate, remarked that he had visited New Zealand soldiers on the battlefield, and was glad to find that the country was represented in the arts of peace as well as those of war.

Every author who writes a research for the *Transactions* must spend much time in its preparation. In most cases he incurs considerable expenditure. From these he reaps no material reward. These researches do much to remove the chance of a charge of intellectual apathy and sluggishness being urged against our country. Above all, they have made and are making every year important additions to the sum of human knowledge.

In whatever way we deal with the present unfortunate financial position in which we find ourselves, we should, in my opinion, take measures to maintain our annual volume without any reduction in size or form. With our limited resources we have done well, and means must be found to maintain our effort with no diminution

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE.

New Zealand Angiosperms.

By W. R. B. Oliver, F.L.S.

[*Read before the Wellington Philosophical Society, 24th September, 1924; received by Editor, 31st December, 1924; issued separately, 6th March, 1926.*]

Plate 1.

Xeronema Callistemon sp. nov. (Plate 1.)

Folia disticha, ensiformia, equitantes, 60–105 cm. long., 3·5–4·4 cm. lat., acuta, multinervata, margine interiore ad basin concava. Scapus 70–120 cm. long., folius pluribus reductis. Racemus 15–30 cm. long., secundus, densiflorus. Bracteae scariosae, acutae, 1 cm. long. Pedicelli patentes, 2 cm. long. Perianthium segmentis, uninervatis, 10–15 mm. long. Filamenta rubra, 20–25 mm. long. Ovarium trigonum, stipitatum; stylus rubrus, 2 cm. long.; stigma obscure tricuspidato. Capsula membranacea, base expansa, loculicide trivalvis, style, staminis et perianthiis segmentis persistentibus. Semina extus papillose, testa nigra.

Xeronema Callistemon forms large tussocks or clusters 1–2 m. in diameter, seated on huge masses consisting of the rhizomes, roots, and dead leaf-bases. The whole plant may thus be nearly 2 m. tall from the rock-surface on which it grows.

Roots filamentous with a tough woody stele and a spongy cortex, 2 mm. diam.

Leaves distichous, equitant, ensiform, acute, multinerved, almost coriaceous in texture. Base of sheath completely overlaps bases of inner leaves; inner edge concave where outer edge of the succeeding inside leaf emerges. Measurements of largest leaf collected: Length, 105 cm.; breadth above sinus, 4·4 cm.; thickness at base, 2·7 cm.

Stem, including raceme, may reach a height of 120 cm. Leaves resemble the radical leaves, but have sheaths very long and apical portion very short. Length of sheath, 25 cm.; of lamina, 9 cm. Of these 3 or 4 are present. From just below raceme to tip the bracts are simple and membranous, without sheaths, the lower of these being about 3 cm. in length. Top of stem, including receme, dark red.

Racemes 15–30 cm. long, secund, 5 cm. diam. Bracts scarious, acute, 1-nerved, 1 cm. long. Pedicels erect, dark red, 2 cm. long. Perianth-leaves, 6, free, alternately wide (3 mm.) and narrow (1·5 mm.), 1-nerved,

10–15 mm. long, red, paler towards the tip. In the unopened flower perianth-leaves are joined along margins, but as stamens grow they are burst apart and then turn back and hang down the pedicel withered but persistent. (Fig. 1.) Stamens 6, filaments bright red, 20–25 mm. long; anthers versatile, filament attached about centre of connective, introrse, splitting along whole length of lobes, orange with a brown margin. Ovary trigonous, shortly pedicellate, green with angles dark purplish-red, lower

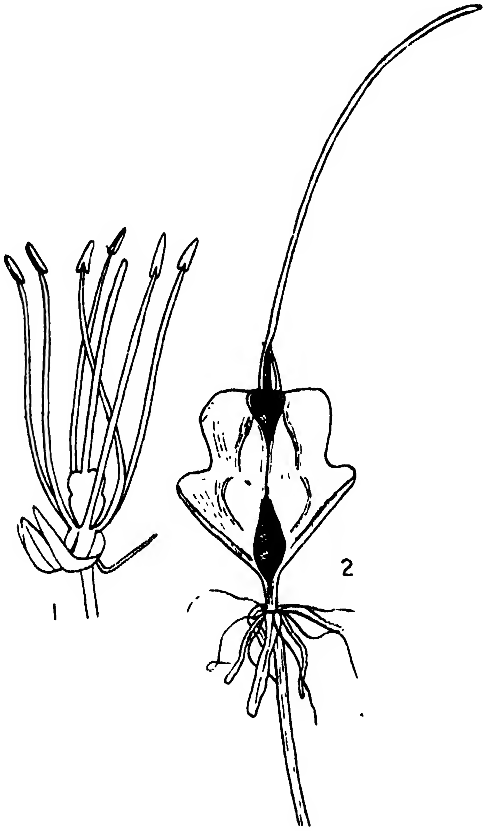

Fig. 1.—Flower of *Xeronema Callistemon* Oliver.
Fig. 2.—Fruit of *Xeronema Callistemon* Oliver.

lobes projecting beyond upper. As fruit ripens, ovary becomes entirely of a deep purplish-red colour. Ovules many, inserted on an axile pink disc in each cell. Style red, grooved at base, grooves corresponding with the 3 sutures at angles of ovary, upper portion with 3 grooves.

Capsule splitting loculicidally above and below. Base of style also splits into 3 for a short distance. Style persistent, erect; stamens and perianth-leaves withered, persistent.

Seeds numerous, trigonous, black, inner faces smooth, outer face roughened with minute papillae.

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The present species is referred to *Xeronema*, a genus hitherto known by a single species, *X. Moorei*, from New Caledonia. *X. Callistemon* is distinguished by its much larger size, by the perianth-leaves being alternately wide and narrow, by the leaves being excavated on the inner edge, and especially by the form of the fruit, which is abruptly produced at the angles just below the centre and dehisces above and below (fig. 2). *X. Moorei* is known to me only by descriptions and figures, but I have little hesitation in describing the New Zealand plant as a distinct though closely allied species of the same genus.

Distribution: *Xeronema Callistemon* is known only from the Poor Knights Islets, off the north-east coast of New Zealand. It is there extremely common on exposed rocky faces on the higher portions of the islands. The huge tussocks can easily be seen from the sea. It was not found in the shade of the forest or near the shore.

Time of flowering: At the time of visit a few flowering racemes only were found, unripe fruit was plentiful, and a few heads of ripe capsules were collected.

Relationships: *Xeronema* now consists of two species, one occurring in New Caledonia, the other in New Zealand. The discovery of *X. Callistemon* adds another species to an interesting group which allies the flora and fauna of New Zealand to that of New Caledonia. Other genera belonging to this group are *Meryta*, *Rhabdothamnus*, *Corynocarpus*, *Agathis*, and *Knightia* among plants, and the land-snail *Placostylus*.

According to Engler's arrangement (*Die nat. Pflanzenf.*, Teil 2, Abt. 5, 1888, p. 38), *Xeronema* is a somewhat isolated member of the Liliaceae, forming with *Herpolirion* the subsection Xeroneminae of the subfamily Asphodeloideae. *Herpolirion* is a monotypic genus of small herbs confined to the mountains of New Zealand, Tasmania, and south-east Australia. The characters in which these two genera agree are the free perianth-leaves, numerous seeds, and distichous leaves.

Xeronema Callistemon was collected by the Dominion Museum expedition which visited the Poor Knights Islands in December, 1924. Shortly after the party landed, Mr. H. Hamilton brought a specimen into camp, and the following day I came across a large patch near the summit of the island. Later Mr. W. M. Fraser, Whangarei Harbour Engineer, who joined the expedition during its stay in the group, and who knew of the existence of this unusual species, piloted us to where the plant grew more abundantly, and good specimens and photographs were taken.

For the opportunity of comparing specimens of *Xeronema Callistemon* with Brongniart and Gris's plate of *X. Moorei* I have to thank the Director of the Sydney Botanic Gardens.

Drimys Forst.

The usage of *Wintera* for the New Zealand species hitherto referred to *Drimys* calls for comment. Hutchinson, in the *Kew Bulletin*, 1921, p. 190, has restricted *Wintera* to the New Zealand species, and used *Drimys* for the remaining species of the genus as generally understood. *Drimys* was founded by J. R. and G. Forster in 1776 (*Characteres Genera Plantarum*, p. 84) for the two species *D. Winteri* and *D. axillaris*. The former belongs to South America, the latter to New Zealand, and both are described and figured in the work mentioned. In 1781 Linné fils (*Suppl. plant Syst. veg.*) uses *Drimys* for *D. granatensis* and *D. axillaris*. This is practically the same usage as the Forsters', for *D. granatensis* is synonymous

with *D. Winteri*. In 1784 Murray (*Syst.*, ed. 14, p. 507) founded the genus *Wintera* for *W. aromaticum* and *W. granatensis*. This clearly leaves *D. axillaris* as the type of *Drimys*. Also, it may be noted, both *W. aromaticum* and *W. granatensis* are South American species, and if the New Zealand species are separated from the others of the genus *Drimys* the name *Wintera* cannot be applied to them—it must remain with the South American species; and if the course taken by Hutchinson in selecting *D. Winteri* as the type of *Drimys* be upheld, *Wintera* would fall an absolute synonym to *Drimys*. Hutchinson's action, therefore, appears to be contrary to the principles of nomenclature. Furthermore, *Wintera* cannot be quoted as of Forster 1786 (*Prodr. Fl. Ins. Austr.*, p. 42), for in the work referred to Forster did not found a new genus, but merely listed *Wintera axillaris* among the species collected by the expedition during Cook's second voyage.

Myosurus novae-zelandiae sp. nov.

Myosurus aristatus (not Benth.) Hook. f., *Fl. Nov. Zel.*, vol. 1, 1853, p. 8: Cheeseman, *Man. N.Z. Flora*, 1906, p. 6.

Sepala 5, calcare brevi. Stamina 5. Spica oblonga, acuta, 6–18 mm. longa. Achenia breviore subaristates.

There are apparently several species of *Myosurus* found in North and South America, mainly on the Rocky Mountains and Andes. The nomenclature of the American species is somewhat involved. The species with which the New Zealand plant has hitherto been united was first described by Gay as *Myosurus apetalus*. This name was dismissed by Hooker as unsuitable because his specimens bore petals, though he afterwards referred New Zealand examples without petals to the same species. However, the New Zealand plant differs in other respects from the American species, so we are relieved of the necessity of deciding either the correctness or suitability of the name to be applied to it.

Specimens from Awatere River, New Zealand, were compared in the British Museum with the Chilian examples collected by Bridges and used by Hooker to establish Bentham's name *aristatus*. The Chilian plant was larger, with longer fruiting receptacles and longer beaks to the achenes. In the Kew Herbarium specimens from Lake Tekapo, New Zealand, were compared with specimens from the Rocky Mountains in Missouri and Oregon, collected by Geyer and determined by Hooker as identical with Gay's *M. apetalus* (*Lond. Jour. Bot.*, vol. 6, 1847, p. 498). In this case the American specimens differed in having long fruiting receptacles, and especially in possessing long beaks to the achenes. The New Zealand species has no petals, whereas Hooker states that all his American specimens possessed them. Some examples both from Chile and the Rocky Mountains approach New Zealand specimens in possessing short fruiting-heads, but in all cases the achenes have long beaks.

Nothopanax kermadecensis n. sp.

Panax arboreum (not Forst.) Cheeseman, *Trans. N.Z. Inst.*, vol. 20, 1888, p. 168.
Nothopanax arboreum (not Seem.) Oliver, *Trans. N.Z. Inst.*, vol. 42, 1910, p. 169.

Affins *N. arboreo* Seem., sed foliis minute sinuato-serratis, petiolulis breviore, umbellis minor.

A large forest-tree, 10 m. tall, with a trunk over 1 m. in diameter and a large rounded head of foliage. Leaves with a sheathing base and slender petiole; leaflets normally 7 in number, elliptic to obovate-elliptic, produced into an acute point, base usually cuneate and often unequal-sided,

margin shallowly sinuate-serrate, lower third entire, slightly wavy. Umbels compact, primary rays 3–5 cm. long, secondary rays 1–2 cm. long.

This species is closely allied to *N. arboreum* of New Zealand, and has hitherto been included with that species; but Dr. Cockayne has recently drawn my attention to its distinctive characters. It differs from *N. arboreum* in the nearly entire leaves, which are more membranous in texture, and in the compact habit produced by the shorter rays to the umbels and the shorter petiolules. Unlike the New Zealand species, it grows into a large tree.

Distribution: Sunday Island, Kermadec Group; in the damp forest on the tops of the hills.

Colobanthus mollis n. sp.

Colobanthus quitensis (not Bartl.) Hook. f., *Handb. N.Z. Flora*, 1864, p. 24; Cheeseman, *Man. N.Z. Flora*, 1906, p. 66.

Planta caespitosa; folia angusto-lineares, acuta, molles: flores tetrameres; peduncules foliis longiores.

After comparison of Chilian examples of *Colobanthus quitensis* in the Kew Herbarium with New Zealand specimens, hitherto included with the South American species, I advance the New Zealand plant as a distinct species. It is characterized by its tetramerous flowers, short flaccid acute or mucronate leaves not exceeding 15 mm. in length, usually much shorter, and by the peduncles being very short, not extending beyond the leaves. *Colobanthus quitensis*, which is found along the Andes from Mexico to Chile, and also occurs in Elizabeth Island, is a much larger plant, the leaves being commonly up to 25 mm. in length, while the peduncles are 50 mm. in length, thus far overtopping the leaves.

Carmichaelia arborea (Forster).

Lotus arboreus Forster, *Prodr. Fl. Ins. Aust.*, 1786, p. 52.
Carmichaelia flagelliformis Hook. f., *Fl. Nov. Zel.*, vol. 1, p. 51, 1853.

Forster's drawing is evidently the plant afterwards described by Hooker as *C. flagelliformis*, and, further, the locality of *Lotus arboreus* and the full description of Forster's quoted by Richard (*Voy. Astrol.*, *Bot.*, p. 345, 1832) leave little doubt that Forster's name should be applied to Hooker's species.

Metrosideros perforata (Forst.) A. Rich.

Leptospermum perforatum Forst., *Char. Gen.*, 1776, p. 72.
Melaleuca perforata Forst., *Prodr. Fl. Ins. Aust.*, 1786, p. 37.
Metrosideros perforata (Forst.) A. Rich., *Fl. Nouv. Zel.*, p. 334.
Metrosideros scandens Sol. ex Gaertner, *Fruct.*, vol. 1, 1788, p. 172.
Further references are given in Cheeseman's *Man. N.Z. Flora*, 1906, p. 167.

The types of Forster's *Leptospermum perforatum* are preserved in the British Museum. They belong to the species generally known as *M. scandens*; and as the specific name *perforata* predates all others proposed for this species, and was taken up correctly by Richard, there seems no good reason for disregarding it.

Descriptions of New Native Plants.

By D. Petrie, M.A., Ph.D., F.N.Z.Inst.

[*Read before the Auckland Institute, 25th November, 1924; received by Editor, 28th November, 1924; issued separately, 6th March, 1926.*]

Plates 2, 3.

Carex McMahoni sp. nov.

Species *C. Buchanani* (Berggren) similis: differt foliis laete viridibus, longe acuminatis, pendentibus: culmis trigonis laevibus, folia permultum excedentibus; spiculis 5–7 crassioribus, ad culmorum apices approximatis sessilibus, duabus supremis masculis: utriculis minoribus, tenuiter plano-convexis, ellipticis, subalatis, plurinerviis, a parte dimidia superiore delicate serrulatis; rostro brevi bifido serrulato.

Densely tufted, dark green; culms numerous, slender, smooth, trigonous, erect below widely drooping above, 90–110 cm. (3–4 ft.) high; leaves considerably shorter than the culms, narrow-striate, keeled, more or less com plicate below, delicately scabrid along edges, slightly recurved in upper half, produced into long acuminate tips; spikelets 5–7, sessile, closely placed at tops of culms, linear-oblong, cylindrical, rather stout, 3–3·5 cm. (1¼ in.) long, 5 mm. broad, the terminal 1 or 2 male (the lower much the smaller and sometimes partially female), the remainder female, a slender and abortive spikelet on a long filiform peduncle often springs from axil of uppermost leaf; bracts long and leaf-like: glumes shorter than utricles, broadly obovate, thin, pale, 1-nerved, wavy and bifid above, produced into a fairly long thin smooth whitish mucro; utricles rather small, shortly stipitate, elliptic, thinly plano-convex, slightly winged along edges, many-nerved on both surfaces, finely serrate along upper half; beak short, bifid, sparsely serrate.

Hab.—Pelorus Valley, Sounds County: J. H. McMahon!

I have pleasure in naming this fine species after Mr. McMahon, who has rendered me many valuable services.

Carex Coxiana sp. nov.

Culmi 45 cm. (18 in.) alti, rigidi erecti triquetri, vix graciles leves, folia vix aequantes; folia linearia, a medio 0·8 cm. (⅜ in.) lata, plerumque plana subcoriacea, utrinque tenuiter ac conferte striata, marginibus subrevolutis, in apices longiusculos filiformes producta; inflorescentia spicula infima duplo longior; spiculae 6–7 approximatae, sursum gradatim breviores, sessiles vel subsessiles robustae fulvae; infima 3 cm. (1½ in.) longa 5 mm. lata, summa mascula claviformis, 3 cm. (1¼ in.) longa, subrobusta; glumae utriculos superantes, ovato-oblongae, plerumque integrae, in aristam brevem levemque productae, apicibus bifidis vel integris; styli 3; utriculi pallidi ± nitentes leves ovoidei, in rostrum subbrevem bifidum angustati, ± plano-convexi, nervis lateralibus duobus percursi, cetera enervia; nux obovoidea, obtuse triquetra, subacuta.

Culms about 18 in. high, stiffly erect, somewhat shorter than leaves, triquetrous, rather slender, smooth; leaves shortly sheathing, almost

linear, keeled near base, flat for most of their length, moderately coriaceous, 3·6 mm. wide at middle, harsh at margins, finely and closely striate above and below, edges somewhat revolute, drawn out into long filiform tips, midrib conspicuous below ; inflorescence twice as long as the lowermost spikelet ; spikelets 6 or 7 approximate near tops of culms, the upper gradually shorter, sessile or nearly so, stout, dark brown, the lowermost 3 cm. (1⅛ in.) long ; topmost male, club-shaped, robust, 3 cm. (1⅛ in.) long by 5 mm. wide, remainder female ; glumes longer than utricles, ovate-oblong, usually entire, produced into a rather short smooth awn, thin, dark brown with a pale striated band along middle, bifid at tops or entire ; styles 3 ; utricles pale, more or less polished and shining, smooth, obovoid, shortly stipitate, rather sharply narrowed into a moderately short bifid beak with slightly diverging teeth, plano-convex or thinly biconvex, with two distinct lateral ribs, otherwise nerveless or with very obscure nerves ; nut somewhat obovoid, bluntly triquetrous, subacute.

Hab.—Chatham Islands : W. Martin !

I have seen only a single specimen, but it is well grown and in good condition. When better known the above description may need amendment.

Carex Martini sp. nov.

Culmi 9–18 dcm. (3–6 ft.) alti, robusti erecti triquetri leves ; folia culmos multum superantia, sublate linearia, a medio 1–1·4 cm. (½ in.) lata, plerumque plana, striata levia, in apices longos filiformes producta ; bracteae foliis similes, multo angustiores, culmi floriger 3–6 dcm. (14 in.) longi ; spiculae 8–12 angustae, longitudine variabiles, 5–8 cm. (2–3 in.) longae, saepe aggregatae, pedicellis axillaribus valde inaequalibus : 4 summae masculae, reliquae femineae supra ± masculae ; glumae perangustae, ovato-lanceolatae, utriculos multum excedentes, in aristam glabram productae ; styli 3 ; utriculi ovato-elliptici, duplo longiores quam lati, in rostrum gracile sublongum angustati, tenuiter biconvexi, utrinque ± costati, colore viridi cinerascenti maculosi ; nux ovoidea.

Culms 3–6 ft. high, stout, erect, sharply and unequally triquetrous, smooth ; leaves far exceeding culms, long-sheathing, linear, 1–1·4 cm. (½ in.) wide at middle, keeled at and near base, flat for most of their length, smooth, coarsely striated above, more finely and closely so beneath, produced into long gently narrowed filiform tips, midrib little conspicuous above, edges smooth, bracts like the leaves but much narrower ; flowering culm 3·6 dcm. (14 in.) long ; spikelets 8–12 (counting the aggregated ones separately), narrow, 5–8 cm. (2–3 in.) long, variable in length : peduncles nearly as long as spikelets, several just exserted from sheaths, frequently aggregated when pedicels vary greatly in length, the shorter spikelets having shorter pedicels ; topmost 4 (rarely compound) male, the others female with a considerable tuft of males at top of each, the lowermost distant ; glumes very narrow, ovate-lanceolate, longer than utricles, continued into a smooth pale awn, entire or wavy at edges, midrib inconspicuous ; utricles ovate-elliptic, twice as long as wide, shortly stipitate, thinly biconvex, two lateral nerves prominent with several finer ones on both faces, narrowed into a moderately long slender straight beak not or scarcely bifid, mottled with greenish-grey ; nut ovoid.

Hab.—Wet and swampy stations at Chatham Islands : W. Martin !

This is a very fine plant. Its range in height may be even greater than here stated. In any case, 6 ft. is the extreme height observed, and such specimens are probably very uncommon. The tallest plant seen grew near the edge of a lagoon and in water of some depth.

Carex McClurgii sp. nov.

Culmi 6–8 cm. (2¼–3 in.) alti, graciles triquetri leves, folia paullo superantes; folia angusta, a medio 5·2 mm. lata, prope basim carinata vel ± complicata, a parte superiore plana, tenuia, levia striata, a marginibus subscaberula, in apices longos filiformes producta; spiculae ad 8; duae ultimae perdistantes, tenuiter pedicellatae, reliquae a culmo summo approximatae, plerumque sessiles; suprema mascula 3–6 cm. longa, reliquae femineae sed ab apicibus ± masculae; glumae utriculos aequantes, tenues acutae pallidae, ovato-lanceolateae, vix aristatae, ab apicibus ± laceratae; styli 3; utriculi anguste elliptici, breviter stipitati, biconvexi vel ± subtriangulares, nervis duobus firmis ac compluribus subtilioribus percursi; rostrum sensim angustatum in apicem acutum breviter vel vix bidentatum.

Culms 6–8 cm. (2¼–3 in.) high, slender, triquetrous, smooth, somewhat exceeding the leaves; leaves narrow, 5·2 mm. wide at middle, below keeled or more or less complicate, for the most part flat, thin, smooth, slightly harsh along margins, striate, drawn out into long filiform tips; midrib prominent below; spikelets 8, 3–6 cm. (1¼ in.) long, rather thin, the two lowermost far apart on long delicate largely ensheathed peduncles, the remainder closely placed near top of culm; topmost male, rather long, the rest female with some male flowers at tops, sessile or nearly so; bracts like the leaves and as long; glumes about equalling utricles, very thin, ovate-lanceolate, acute, pale straw-coloured, awnless or nearly so, more or less lacerate at tops; styles 3; utricles narrow elliptic, shortly stipitate, biconvex or subtriangular, with two strong lateral nerves and numerous finer ones; rostrum gently narrowed to the acute shortly or barely bidentate beak; nut oblong, obtusely trigonous.

Hab.—Chatham Islands: W. Martin! January, 1924.

Mr. Martin obtained a great deal of important help and information about the island plants from Mr. McClurg, who knows almost all the native plants, with their Moriori names.

Carex rekohu sp. nov.

Culmi ad 54 cm. (20 in.) alti, obtuse trigoni leves; folia culmos aequantia, a medio c. 10 mm. lata, coriacea vel subcoriacea, pro parte majore complicata et a marginibus recurva, raro apicem versus plana, in apices filiformes angustata; bracteae foliis consimiles ac aequilongae. Spiculae ad 10, 4 supremae masculae sessiles valde approximatae, subcrassae; reliquae foemineae saepe compositae a parte terminali ± masculae, infima 6·5 cm. (2½ in.) longa, longe pedunculata, crassior distans, superiorum pedunculi breviores, 2 vel 3 summae sessiles; glumae utriculos aequantes, alte bifidi, nervo medio pallido percursae, costa media in aristam hispidam pallidam producta; utriculi anguste obcuneati, rostrum subconicum brevissime bifidum, nervi laterales duo validi, caeteri obscuri et saepe paene obsoleti. Nux obtusa trigona anguste oblonga.

Culms up to 54 cm. (20 in.) high, obtusely trigonous, smooth, moderately stout; leaves about as long as culms, *c.* 10 mm. wide at middle, gradually tapering to filiform tips, complicate and more or less recurved at

edges, rarely flat in terminal third, smooth deeply striate; midrib prominent below; bracts like the leaves and as long, the lowermost long sheathing. Spikelets usually 10, the four topmost male, sessile, very closely placed, rather stout, the others female with some male flowers at tips, lowermost 6·5 cm. (2½ in.) long, long pedunculate, stout, distant, those above with shorter pedicels, the two or three topmost sessile; glumes about equalling utricles, rather narrow-oblong, bifid above, with one strong median nerve a dark brown strip on either side with pale margins, midrib prolonged into a pale hispid awn as long as glumes. Styles 3. Utricles narrow obcuneate, stipitate, sharply contracted at tip into a conical very shortly bifid beak with very short erect teeth, polished and when mature almost black, with two strong lateral nerves and several faint and almost obsolete nervures between. Nut bluntly trigonous, narrow-oblong.

Hab.—Chatham Islands: W. Martin!

The specimens collected January, 1924, were much overripe, and most of the glumes and utricles had fallen off.

Carex rotoensis sp. nov.

Calmi 15 cm. (6 in.) longi, teretes graciliores leves; folia culmos paene aequantia, linearia, infra ± complicata plerumque plana, striata, a medio 3 mm. lata, marginibus apices versus tenuiter scabridis; spiculae 6, distantes sessiles, c. 5 mm. (¾–¼ in.) longae, sursum regulariter abbreviatae, pallidae, ultima breviter pedicellata; summa mascula 11 cm. (1¼ in.) longa, reliquae femineae; glumae utriculos superantes, ovato-lanceolatae acutae, plerumque integrae, a medio pallidae a marginibus subfuscae vix mucronatae; styli 3; utriculi plano-convexi vel subtriquetri, haud vel vix stipitati, ovoidei politi, enerves vel nervis perobscuris; rostrum moderate breve sublate bifidum; nux triqueter.

Culms 6 in. long, terete, rather slender, smooth; leaves numerous, about as long as culms, the outermost short and scale-like, acute or acuminate, strongly striate; older ones linear complicate or keeled below, flat for most of their length, 3 mm. broad at middle, finely scabrid along edges of upper part, narrowed into fine points; spikelets 6, distantly placed save at tops of culms, sessile or the lowermost shortly pedicellate, gradually shorter upwards, ¼–¾ in. long; topmost male, 1¼ in. long, the others female; glumes longer than utricles, ovate-lanceolate, thin and membranous, usually entire rarely shortly bifid at or near tips, pale along the middle, more or less brown at sides, midrib prominent, scarcely mucronate; styles 3; utricles plano-convex or subtriquetrous, not or hardly stipitate, ovate, polished, nerveless or almost so; beak moderately short rather widely bifid; nut triquetrous.

Hab.—Te Roto, Chatham Islands: W. Martin!

Only a single specimen of this was available for examination, but it was in good condition. Further specimens may show occasion for amendments in the description.

Schoenus caespitans sp. nov.

Species dense caesptans depressa *c.* 4 cm. (1–1½ in.) alta. Folia a bas erecta, filiformia, culmos aequantia vel excedentia, basi ± expansa ac vaginantia; culmi foliis crassiores virides erecti; inflorescentia brevis capituliformis; capitulum parvum sublonge bracteatum, e fasciculis tribus 8–10 florigeris arcte aggregatis compositum; glumae distichae, 3 inferiores

vacuae, quarta florem hermaphroditum gerens, summa vacua raro staminifera: stamina 3; setae plerumque 3; stylus erectus supra in ramos 3 divaricantes divisus; spiculae culmique maturi haud visi.

A densely-tufted depressed species 4 cm. (1½ in.) high, forming low patches of considerable size. Leaves numerous, filiform, glabrous, more or less involute, delicately scabrid at tips, equalling or exceeding culms, expanded below and more or less sheathing; culms twice as stout as leaves, erect, green; inflorescence compact, dark brown, composed of 2–3 sub-umbellate closely-placed clusters of 8–10 flowers; cluster-bracts subulate, long, green much exceeding flower-clusters; spikelets small, lanceolate, nearly sessile; glumes distichous, ovate, acute, dark brown with whitish edges and a whitish median tract along back, three lowermost empty, the fourth with a perfect flower, the fifth empty rarely staminiferous; bristles usually 3; stamens 3, sagittate; style erect with 3 strongly divaricating branches: mature culms and spikelets not seen.

Hab.—Ure Valley, Marlborough: Arnold Wall!

The culms probably elongate after flowering. One of the most interesting of Professor Wall's recent discoveries.

Muehlenbeckia debilis sp. nov.

Species *M. complexae* (Meissner) affinis; differt caulibus gracilioribus viridibus vel cinerascenti-viridibus, ubique glaberrimis, ramis ramulisque distantibus subdivaricatis pergracilibus, foliis multo angustioribus plerumque lineari-lanceolatis acuminatisque, floribus in spicis simplicibus dispesitis, perianthо in fructu maturo herbaceo haud incrassato.

A branching perfectly glabrous shrub, forming low widespreading more or less entangled scrambling sheets in moist stations, or broad erect and finally pendulous dense rush-like tufts on gravelly terraces (where they are usually much eaten back by stock). Stems up to 15 dcm. (38 in.) long in moist stations, much shorter on gravelly terraces, slender, tough, terete, striate, green or greyish-green, quite glabrous, giving off (in the scrambling form) numerous distant very slender alternate subdivaricating branches and branchlets, with rather long simple ultimate flower-bearing twigs; leaves chiefly on ultimate twigs, more or less distant, usually linear-lanceolate and acuminate, entire, 10–20 mm. (7/16–13/16 in.) long (rarely shorter and contracted about the middle with rather wide basal lobes), suddenly narrowed into slender petioles about ⅓ as long as the blades; sheathing stipules conspicuous, thin, yellowish, more or less persistent. Spikes axillary and terminal, simple, narrow, 3–4 cm. (1½ in.) long in male plants, shorter in female ones; flowers closely placed, alternate, almost sessile in axils of broad subacute yellowish sheathing scales, small, dioecious; males with 8 stamens and perianth deeply cut into semihyaline narrow-oblong obtuse divisions; females with somewhat broader perianth-lobes, 8 staminodia and sparingly fimbriate stigmas; fruiting perianth not enlarged or succulent; nut black and shining, deeply triquetrous.

Hab.—On low gravelly terraces and the immediate banks and rocky faces of the Awatere and Grey Rivers, close to the Homestead of Upcot Station, Middle Awatere, Marlborough.

Flowers in February. Male plants seem to be much more plentiful than female ones. This may be due to the general absence of flowers on the plants scattered over the gravelly terraces, most of which are eaten back to below the level at which the inflorescence appears.

Ranunculus Carsei sp. nov.

Species parva prostrata sparse pilosa; culmi complures pro plantae mangitudine robustiores; petioli graciles ± 1·7 cm. longi, basi vaginantes, vaginis copiose pilosis; laminae 6 mm. latae 5 mm. altae, laeves, forma variabiles, plerumque late triangulares 3-lobatae, lobis varie divisis; flores in anthesi parvi axillares sessiles, maturorum pedicellis ad 2 cm. productis; sepala 5 laevia 1-nervia, scariosa ovata; petala pauca (2 vel 3 ut videtur), longiuscula anguste obcuneata; stamina pauca; achenia parva late obovata, biconvexa, ± atro-fusca; rostrum perbreve erectum.

A small prostrate sparsely-pilose plant growing on dripping rocks or similar wet situations. Roots numerous, slender; stems several, short, c. 5 cm. (2 in.) long, rather stout for size of plant: leaves on slender petioles 1·7 cm. (⅝ in.) long, petioles expanded and sheathing at base, sheaths copiously pilose; blades 6 mm. broad, 5 mm. long, thin, variable in cutting, general outline broadly triangular usually deeply 3-lobed, lobes more or less subdivided, terminal lobe sometimes cut like the main lamina; flowers small, axillary, at anthesis sessile or nearly so, in fruit with peduncles longer than the petioles; sepals 5, thin, glabrous, scarious, 1-nerved, ovate, somewhat boat-shaped; petals few (apparently 2–3), rather long narrow-obcuneate, upper part bright yellow; stamens few, anthers small and terminating filaments; achenes small, broadly ovate biconvex, upper parts more or less mottled with blackish brown; beak straight, inconspicuous.

Hab.—Mounts Tongariro, near the base: H. Carse!

Flowers in January. A very peculiar and distinct species. It has no close ally in the New Zealand species of the genus known to me.

Notothlaspi rosulatum (Hk. f.) var. **Hursthousei** var. nov.

Planta c. 22 cm. (8–9 in.) alta, purpurata, quam forma typica altior ac robustior, a basi inflorescentiae emittens supra folia c. 12 graciles breviores paucifloros ramos; flores subflavidi, petalis purpureo ± tinctis.

Plant 8–9 in. high, everywhere purplish, longer and stouter than the typical form; radical leaves very numerous, long-petiolate; from base of the ordinary terminal inflorescence about 12 slender rather few-flowered branches spread out just above leaves; main axis of inflorescence 6–7 in. long, erect, flowers and capsules closely crowded throughout its length; flowers cream-coloured, tips of petals tinged with purple; capsules larger than in type.

Hab.—Shingly Range near Molesworth Station, Upper Awatere. Marlborough: F. H. Hursthouse!

Only a single specimen of this remarkable form has been seen by me, and when better known it may prove worthy of specific rank. Mr. Hursthouse, who is an excellent observer, writes: "It grows at a height of about 4,000 ft. on shingly faces that are visible from Molesworth Homestead. There were many fine specimens, like the one I have sent, which stood up like little manikins on the bare shingle." Further specimens will be awaited with interest.

Pimelea laevigata Gaert. var. **monticola** var. nov.

Rami numerosi a radicibus quoquoversus sublate patentes, graciles, decumbentes, haud vel vix radicantes; ramulis multum subdivisis, pilis

sericeis brevibus subdense vestitis; folia ± patentia, oblongo-elliptica, subacuta, paene sessilia, glabra, latitudine quam longitudine dimidio minore, costa media infra conspicua; flores colore subpuniceo ± tincti.

Branches numerous, spreading widely all round from top of roots, slender decumbent or almost prostrate, glabrous in lower parts; branchlets much subdivided and clothed rather closely with short silky hairs; leaves smooth, patent, oblong-elliptic subacute, almost sessile, glabrous, about ½ as wide as long; midrib conspicuous on under side; flowers stained with pink, floral leaves slightly larger than cauline.

Hab.—Hauhungatahi, Waimarino Plateau, *c.* 3,800 ft.: H. Carse and H. B. Matthews! Mount Tongariro: B. C. Aston!

Originally sent me by Mr. B. C. Aston, who considered it a new species. It is, however, very close to Gaertner's species, and is for the present ranked only as a variety. It is always a plant of more open growth with leaves much less glossy than in the type.

Nothopanax McIntyrei sp. nov.

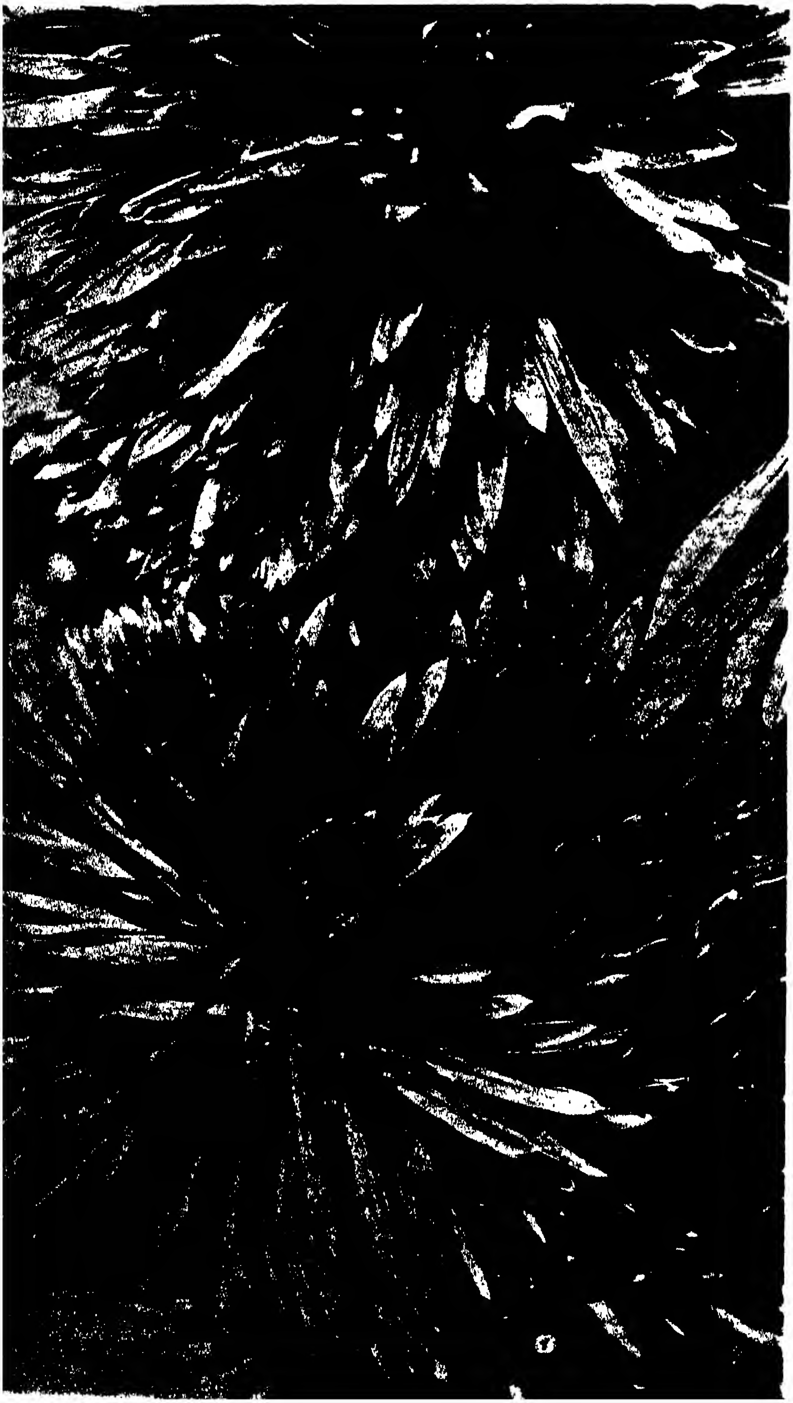
Arbor subhumilis ± glaber paene a basi fastigiate ramosus. Folia alterna, coriacea, satis distantia, trifoliolata; petioli ad 3·5 cm. (1½ in.) longi; foliola petiolos breviter superantia, sessilia, elliptica, laete viridia supra, infra pallidiora, ad basim gradatim attenuata, acute ac subconferte serrata, subacuta, costa media evidens supra infraque. Inflorescentia umbellata, axillaris (rarius terminalis); rami principales plerumque solitarii erecti graciles, in ramos secundarios complures divaricantes 2 cm. (¾ in.) longos divisi, denuo subdivisi in umbellulas minores 18 mm. (¾ in.) latas, flores parvos breviter pedicellatos 6–8 gerentes. Styli 2; fructus maturus suborbicularis, ± complanatus, c. 5 mm. diam.

A rather glabrous small tree, fastigiately branched from near the ground. Bark blackish-brown; leaves alternate, rather distant, trifoliolate, dark green above paler below; petioles about 3·5 cm. (1½ in.) long (sheaths short stem-clasping); leaflets coriaceous, slightly longer than petioles, sessile or nearly so, elliptic, gradually narrowed to base, sharply and coarsely serrate for ⅔ their length, subacute, midrib evident above and below, nerves obscure. Inflorescence umbellate in axils of upper leaves, more rarely terminal, dioecious; primary branch usually solitary and erect, divided into several (6 or fewer) strongly divaricating secondary branches, which are again subdivided into smaller umbellules bearing 6–8 shortly pedicellate flowers. Styles 2, short, slender; male flowers not seen; mature fruits suborbicular flattened, 5 mm. in diameter.

Hab.—Grown in Dr. Hunter's garden at Mornington, Dunedin, and said to have come from Westland: W. A. Thomson.

Mr. Thomson has transmitted specimens of this to me. The species is named in honour of Mr. J. W. McIntyre, who has had charge of the above garden for many years, and has had great success in growing alpine and other rare plants sent on from time to time by Mr. H. J. Matthews, by whom this fine garden of native plants was established. The pieces seen all belong to the female plant. It has been in the garden nineteen years, and is now a small tree about 8 ft. high. The trunk just above the ground is 15 in. in circumference. Several young plants have grown up near its base.

iphylla Sm



'a Crosby-Smithii

Aciphylla Crosby-Smithii Petrie. (Plates 2, 3.)

A preliminary notice of this species was published in *Trans. N.Z. Inst.*, vol. 47, p. 48. Thanks to the kindness of Mr. James Speden, of Gore, and Mr. H. L. Darton, of Lawrence, a full-grown plant (not in flower) has been obtained, which is shown herewith in two photographs of different scales. It is thus possible to add some important particulars to the original notice. The natural size of the whole plant is 14 in. by 11 in., and each of the six rosettes is 5 in. in diameter.

Stem erect from root, nearly as thick as a man's thumb, short (*c.* 8 in.); main branches 3 approximate, the lowermost about 2 in. up stem, subdivided above and nearly as stout as stem, closely covered with more or less withered leaves and ending in large rather flattened or rounded rosettes or heads each 4 in. or 5 in. across, and covered with very numerous most densely compacted leaves. Leaves spreading all round, about 3 in. long, the lower half broadly sheathing, sheaths very thin and glabrous, basal spines like the leaflets; leaflets in 3 to 5 pairs, linear-oblong subacute with a short abrupt pungent mucro, channelled above, 1-nerved, thickened at the margins. Flowering-stem rather thin (*c.* 5 mm. in diameter), about 8 in. high, brownish-red, deeply striate; involucral scales thin and flaccid, sheaths longer than leaf-like part; primary umbels numerous, slender, about 1 in. long; secondary small with many almost filiform pedicels; fruits all shed and no flowers seen.

Hab.—Princess Range, Fiord County, *c.* 4,600 ft.: James Speden! H. L. Darton!

A most remarkable plant, as the photographs sufficiently show. It probably flowers but rarely. No known native *Aciphylla* resembles it in habit of growth. The old flowering-stems came from other plants than those shown in the illustrations.

Schizeilema Allanii sp. nov.

Species *S. pallidae* (Domin) consimilis; differt rhizomate longiore, foliis multo majoribus semiorbicularibus infra pallidis; petioles multo longioribus a marginibus subcartilagineis; umbellis plerumque duabus raro singulis vel tribus; fructibus majoribus, foliis involucratibus apicem versus ± dilatatis.

A matted pale-green perfectly glabrous plant very similar to *S. pallida* (Domin); rhizome up to 5·3 cm. (12 in.) long, slender, flaccid, with 1 to 3 distant rooting-nodes generally more or less leafy; radical leaves not numerous, petioles rather slender flaccid brownish, up to 6 in. long; blades semiorbicular in outline, 3·8 cm. (1½ in.) wide, ¾ in. long, more or less polished, rather pale green above much lighter below, little coriaceous, variable in cutting, usually trifoliolate but sometimes only more or less deeply trifid or tripartite at tips, segments obcuneate usually with 3 to 4 shallow rather broad subcrenate indentations at tips, margins thinly cartilaginous, slightly incurved when dried, veins obscure above evident below; peduncles rather distant, almost filiform, shorter than petioles, the primary at first terminal, later overtooped by a decumbent branch from the axil of a small entire or trifid bract, the same formation being repeated a second or even a third time, secondary umbellules occasionally present; peduncles short very slender, pedicels nearly as long capillary; involucral leaves linear somewhat expanded near tips; flowers 8–12 in

each umbel; fruits (still rather immature) shortly and broadly oblong, obtusely 4-angled, deeply furrowed at commisures.

Hab.—Maharahara Mountain, near south end of Ruahine Range: H. H. Allan!

I have to thank Dr. Allan for a good series of specimens.

Gentiana Spedeni sp. nov.

Planta perennis erecta glaberrima, culmos solitarios longiusculos gerens; folia radicalia numerosa, conferta, arcto imbricantia, subrosulata spathulata integra, 1 cm. (¼–⅜ in.) longa; pars petiolaris quam lamina bis terve longior, lamina ovata subacuta, parum coriacea, integra, nervo medio evidente supra infraque, cetera enervia; folia caulina 8–10 mm. longa in paribus duobus distantibus disposita, pari superiore ⅓ culmi longitudinem aequante; culmus simplex teres pergracilis, 14 cm. (5¼ in.) longus; bracteae florales 4, sessiles ovatae congestae; flores 4 pedunculati, pedunculi 7 mm. (c. 1½ in.) longi, ex bractearum axillis editi. Calyx alte in lobos 5 angustos acutos sectus; petala 5 calyce ⅓ longiora, late obovata obtusa, venis subparallelis purpureis percursa; pistillum apice 2-lobatum. Capsula haud visa.

A slender glabrous plant with solitary culms, numerous subrosulate spathulate radical leaves, and terminal umbel-like clusters of 3 or 4 flowers. Base of stem nearly horizontal, slender, naked, closely scarred, dark brown; radical leaves crowded, overlapping, entire, 1 cm. (¼–⅝ in.) long; petiolar part 2–3 times as long as the laminar, flattened; lamina ovate, subacute, little coriaceous, entire, nerveless but for the evident midrib; cauline leaves in 2 pairs, the lower a little above the radical, the second ⅓ way up the stem, small, subsessile; stem simple, terete, very slender, 14 cm. (5¼ in.) high; bracts 4, crowded, obovate, sessile, each subtending a flower; flowers 4, forming a terminal cluster 1·5 cm. (*c.* ½ in.) long; peduncles almost capillary, about equalling the flowers; calyx cut almost to the base into 5 broadly-linear acute segments; petals ⅓ longer than calyx, broadly obovate, traversed by numerous subparallel "purplish or violet" (J. Speden) veins; stamens ¼ length of pistil, filaments about equalling anthers; pistil shortly two-lobed at top.

Hab.—Princess Range, Fiord County, *c.* 4,000 ft.: James Speden!

Early January, 1924; rare. Only a single plant of this very beautiful and distinct species has been seen. Mr. Speden reports that only a few plants were observed, and that flowering ones were extremely rare. It would probably make a fine garden-plant.

Gentiana amabilis sp. nov.

Herba nana, ad 4–5 cm. (2¾ in.) alta, perennis (?), in locis palustribus crescens. Caules solitarii, a radice erecti vel ± flexuosi, flores singulos terminales gerentes; folia radicalia subspathulata; laminae 1·5 cm. (⅝ in.) longae 6 mm. latae, anguste ellipticae, tenues subacutae, in petiolos ± aequilongos ± complanatos angustatae; caulina sessilia, in paribus duobus subdistantibus disposita; flores magni albi, 1·8 cm. (¾ in.) longitudine ac latitudine; calyx corolla dimidio brevior; corolla alte secta, lobis late obovatis; stamina corolla dimidio breviora, antheris ± complanatis ac basim versus dilatatis; pistillum in anthesi staminis aequilongum; stigma breviter bifidum.

A dwarf herb 4·5 cm. high, perennial (?), growing in boggy ground. Stems solitary, slender, dark brown, erect or more or less flexuous, often laterally placed through rapid growth of a side shoot (rarely once divided and bearing 2 flowers); radical leaves subspathulate, with narrow more or less elliptic thin acute entire blades, 1·5 cm. (⅝ in.) long and 6 mm. wide, and somewhat flattened slightly expanded at base; petioles equalling blades or shorter; cauline in 2 rather distant pairs, narrower and smaller, sessile or nearly so; flowers solitary, terminal, large for so small a plant, white, 1·8 cm. (¾ in.) long and as wide; calyx scarcely half as long as corolla, cut half-way down into broad-based acute lobes; corolla deeply divided, segments broadly obovate; stamens half as long as corolla; anthers flattened and expanding below; pistil about equalling stamens; stigma shortly 2-lobed.

Hab.—Bogs at the top of Mount Tennyson, Garvie Range, Southland, 4,800 ft.: W. A. Thomson!

Mr. Thomson has supplied a good series of specimens, which are most uniform in their characters.

× **Veronica Bishopiana** species hybrida nova. (*V. salicifolia* Forst. × *V. obtusata* Cheeseman.)

Frutex humilis habitus aperti; caules c. 60 cm. alti, infra secundum solum patentes ac saepe a nodis radicantes, deinde ascendentes vel ± erecti, graciles apices versus purpurei ± ramosi; folia decussata anguste lanceolato-elliptica, 5–8 cm. (3 in.) longa c. 2 cm. (⅘ in.) lata, glabra sessilia acuta; racemi e foliorum superiorum axillis, infra nudi, graciles glabri, 8–11 cm. (4 in.) longi; flores dense congesti, breviter pedicellati; stamina stylique longe exserti corollam duplo superantes; capsulae subparvae deflexae ovoideo-ellipticae.

A straggling low shrub of open habit growing on bare or mossy rocks. Stems about 2 ft. high, several spreading more or less closely to the ground and often rooting at nodes, then ascending or nearly erect, slender, glabrous, dark purple, considerably branched near extremities; branches spreading at a wide angle, not further subdivided; leaves decussate, moderately distant, narrow lanceolate-elliptic, 2–3 in. long, ½–¾ in. broad, glabrous, sessile, sharply acute; racemes in the axils of the upper leaves, naked below slender glabrous, 3–4½ in. long, about ½ in. broad; flowers closely crowded, shortly pedicellate, rather small; stamens and styles strongly exserted, twice as long as corolla; capsules rather small, deflexed, ovoid-elliptic.

Hab.—Rocky knobs between Huia Hill and Little Huia, near Manukau North Heads: J. J. Bishop! H. Carse! E. Jenkins! April, 1924.

Mr. Bishop has had this plant in cultivation for several years, having transferred young wild plants to his garden, where its position and relations have hitherto puzzled observers. Both the parent species grow on the coast west of the Waitakerei Range as far as Manukau Heads, *V. salicifolia* being much the more plentiful. *V. obtusata*, in this district, grows on coastal cliffs and on rocky hummocks in the forest often some way back from the sea.

Euphrasia Hectori sp. nov.

Rami complures a radice patentes ac radicantes, 8 cm. (3 in.) longi vel ultra, ramulos complures laterales breves e foliorum axillis edentes;

folia in paribus oppositis disposita, ± approximata punctata, anguste obovata, subspathulata, connata, culmos ± vaginantia, sub apice obtuse breviterque 3-dentata, obtusa; culmus florigerus ascendens, deinde erectus; bracteae sessiles, in paribus duobus distantibus dispositae, subtriangulares apicibus breviter 3-lobae; flores majusculi, solitarii, ex superiorum bractearum axillis orientes; pedicellis capillaribus simplicibus, ± pendulis; calyx corollae tubo lato ½ brevior, ad medium in segmenta obtusa 4 secta; corollae labium superius alte 3-loba, inferius fere ad basim 2-laba, lobis obtusis; capsula anguste ovata, acuta; pistillum capsulam subaequans.

Branches several from the root, spreading and rooting, 8 cm. (3 in.) long or more, light brown, terete, glabrous, giving off short lateral branches from axils of leaves and terminating in a slender ascending or erect inflorescence; leaves in opposite pairs 1·5 cm. (½ in.) apart or less, narrow obovate-spathulate, connate, and stem-clasping at base; petiolar part thin, rather broad, flat or slightly incurved at scantily ciliate edges, about ⅓ as long as entire leaf; laminar part thicker, narrow obovate with 2 shallow rounded teeth near obtuse tip, punctate on both surfaces, glabrous, vivid green above, paler below, the edges slightly recurved; mid-rib evident above and below; flowering-stems erect or ascending from the ends of branches, very slender, dark brown; cauline leaves in 3–4 distant pairs, sessile or the lowermost nearly so, coriaceous, subtriangular shortly 3-lobed at tips; flowers large, springing singly from axils of uppermost bracts, pedicels capillary about 2·5 cm. (1 in.) long, dark, simple, drooping more or less; calyx about ⅔ as long as the broad corolla-tube, cut half-way down into 4 oblong obtuse segments; corolla white, large, 2 cm. (¾ in.) long and nearly as broad, upper lip deeply 3-lobed, lobes obtuse, lower 2-lobed to base, lobes obtuse; capsules (rather immature) as long as sepals, narrow ovate acute; pistil about equalling capsule; seeds not seen.

Hab.—Haast Valley, South Westland: R. A. Wilson!

The specimen described is incomplete, but the characters above set forth show it to be very distinct. The specimen was forwarded to me by Mr. B. C. Aston, F.N.Z.Inst.

Petalochilus: a New Genus of New Zealand Orchids.

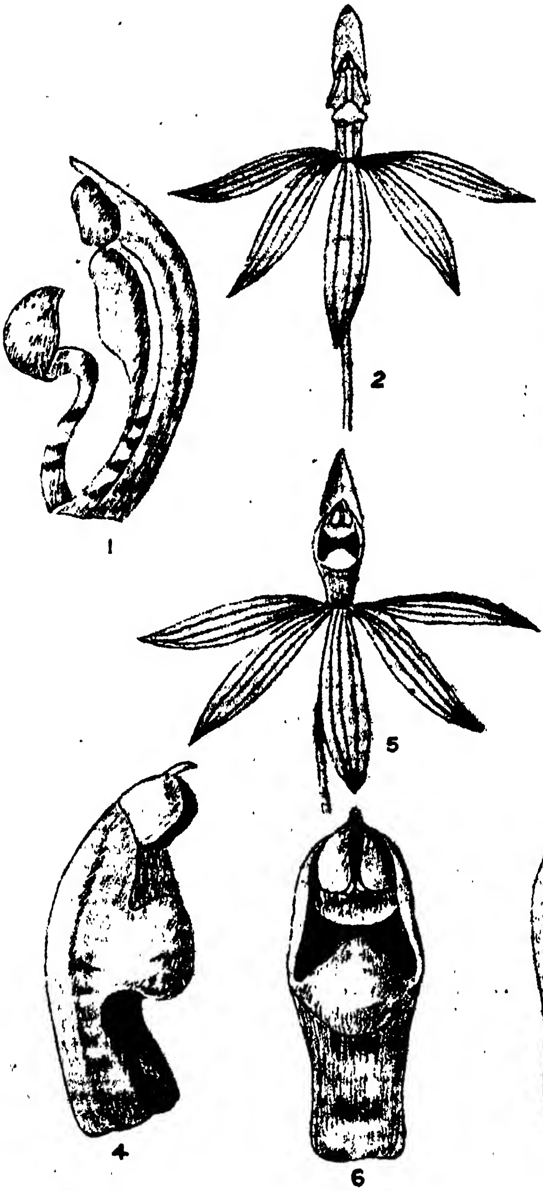
By R. S. Rogers, M.A., M.D.

[Reprinted from the *Journal of Botany*, March, 1924, on the suggestion of D. Petrie.]

Plate 4.

Petalochilus nov. gen.

Herbae terrestres, hirsutae, tuberibus globulosis parvis, caule simplici 1-foliato. Folium ad basin, lineare. Flores pedicellati, 1 vel 2. Segmenta perianthii subaequilonga, fere similia, angustiuscula; posticum erectum vel leviter incurvum, cetera plana et patentia. *Labellum ceteris segmentis simile* sed breviusculum. Columna elongata, leviter incurva; in parte superiore late alata; inferiore anguste alata. Anthera suberecta,



FIGS. 1–3.—*P. calyciformis*. FIGS. 4–7.—*P. saccatus*.

, Column from the side, showing appendage; 2, front view of the flower (the artist has represented the labellar segment too long); 3, column from the front, showing appendage; 4, column from side, showing anterior union of the columnar wings; 5, front view of flower (the artist has shown the labellar segment too long); 6, column from the front, showing the union of the wings to form a pouch; 7, column from the back. All details much enlarged.

bilocularis, mucronata; pollinia pulverea; caudiculae nullae. Stigma sub antheram, concavum.

Species nobis notae 2, Novae Zelandiae incolae.

Leaf basal, linear. Flowers pedicellated, 1 or 2. Segments of perianth subequal, similar, rather narrow; the dorsal one erect or slightly incurved over the column, the others flat and spreading; labellum similar to the other segments but slightly shorter. Column elongated. slightly incurved, widely winged above, narrowly below. Anther suberect, 2-celled, mucronate; pollinia powdery; caudicles absent. Stigma concave, just below the anther.

Terrestrial hairy herbs, with small globular tubers.

The outstanding feature of the new genus is, of course, the ancestral form of the labellum.

The excellent vernacular names, *cup* and *pouch orchid*, originally applied by the discoverer, Mr. H. B. Matthews, have been latinized and retained as specific designations for its two representatives.

The plants are endemic to New Zealand, and, so far as is known, are restricted to the neighbourhood of the little town of Kaitaia, situated in the extreme north-east of the Dominion.

The peculiar appendage in the first species is probably staminodial in origin, and occupies the position of stamen a_3 of the inner whorl. In *P. saccatus* the size and shape of the capacious pouch suggest that the wings of the column are not its sole constituents, but that the staminode is also a component part.

Superficially both species bear a striking resemblance to the diminutive orchid *Caladenia minor* Hook. f., which is likewise endemic to the same islands.

The affinities of the new genus are certainly with *Caladenia* rather than with *Thelymitra*, with which it has few features in common beyond the hitherto unique distinction of an undifferentiated labellum. The Apostasieae, in which, of course, the labellum is also undifferentiated, must be regarded only as doubtful members of the Orchidaceae. It also approaches very closely to *Glossodia*, especially if it be admitted that the pouch in *P. saccatus* represents a fusion between the wings of the column and the staminode. In the living state, however, there is little that is reminiscent of that genus in which the labellum, although almost quite plain, is nevertheless very dissimilar in appearance to the petals, and the basal appendage is either bifid or distinctly dual in character.

Mr. Matthews has had these orchids under observation since the year 1912. He says that both species were plentiful, that they seeded freely, and showed practically no variations. On one occasion he collected about a hundred specimens of *P. calyciformis* and seventy of *P. saccatus*. In January, 1919, he wrote stating that he had recently visited Kaitaia, and found that in all three places where previously he had been accustomed to collect the *cup-orchid*, the tea-tree (*Leptospermum scoparium*), among which it grew, had been cleared for agricultural purposes. Thus, unless a fresh locality should be discovered, this interesting plant will be no longer available to students of botany.

Column-wings open anteriorly, not connate; a linear sigmoid appendage, with a cup-shaped summit, erect against the column .. .. 1. *P. calyciformis*.

Column-wings connate anteriorly throughout their entire length, forming a pouch .. .. 2. *P. saccatus*.

1. **P. calyciformis** n. sp.

Gracillima, circiter 7–22 cm. alta. Folium anguste lineare, fere glabrum, circiter 4–15 cm. longum. Caulis gracillimus, hirsutus, infra vel ad medium bractea lineari-lanceolata instructus. Flores 1 vel 2, subvirides, circiter 12–13 mm. in diametro. Ovarium elongatum subvillosum. Segmenta perianthii subacuta, 5-nervosa, circiter 6 mm. longa; labellum ceteris segmentis breviusculum et aliquando latiusculum. Columna circiter 5 mm. longa, in parte superiore late alata. Appendix longiuscula linearis sigmoidea, apice calyculo instructa, ante columnam erecta.

N.Z.: Kaitaia, County Mongonui, H. B. Matthews, 27 Oct. - 15 Nov., 1916.

A very slender plant, about 7–22 cm. high. Leaf very narrow linear, nearly glabrous, basal, from 4–15 cm. long. Stem very slender, hairy, a loose linear-lanceolate bract at, or a little below, the middle. Flowers greenish, about 12 13 mm. in diameter, usually single, but occasionally 2, the very slender pedicel subtended by a narrow acute bract. Ovary elongated, rather hairy. Segments of the perianth not very acute, pubescent-glandular on the outside, 5-nerved; the dorsal one erect or slightly incurved, the others spreading; about 6 mm. long; the labellar segment a little shorter than the rest and sometimes a little wider. Column about 5 mm. high; winged throughout, rather widely in the upper half, narrowly below. A linear appendage with sigmoid flexure, furnished with a little cup at the apex, erect in front of the column.

2. **P. saccatus** n. sp.

Gracillima, circiter 7–14 cm. alta. Folium anguste lineare, fere glabrum, cauli subaequilongum. Caulis hirsutus, supra medium bractea acuta instructus. Flos solitarius, carneus, circiter 2 cm. in diametro. Ovarium elongatum, villosum. Segmenta perianthii subacuta, 5-nervosa, circiter 10 mm. longa; labellum breviusculum et aliquando latiusculum. Columna circiter 4·75 mm. longa; alae antice connatae, saccum membranaceum formantes.

A very slender species, about 7–14 cm. high. Leaf almost glabrous, narrowly linear, usually about as long as the stem. Stem very slender, hairy, with an acute bract above the middle. Flower pink, solitary, about 2 cm. in diameter, its pedicel subtended by a narrow acute bract. Ovary elongated, rather hairy. Segments of perianth not very acute, the sepals glandular-pubescent on the outside, 5-nerved, a pink stripe down the middle; the dorsal one erect or slightly incurved, the others spreading; about 10 mm. long; the labellar segment a little shorter than the rest and sometimes a little wider. Column about 4·75 mm. high with transverse pink bars; the wings uniting behind the anther, coalescing throughout anteriorly, so as to form a well-marked membranous pouch below the stigma.

N.Z.: Kaitaia, Mr. H. B. Matthews, 10–31 Oct., 1917.

A Proposed New Botanical District for the New Zealand Region.

By L. COCKAYNE, Ph.D., F.R.S., F.N.Z.Inst., and H. H. ALLAN, M.A., D.Sc., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 12th November, 1924; received by Editor, 31st December, 1924; issued separately, 6th March, 1926.*]

IN 1921 (*The Vegetation of New Zealand*, p. 303) L. Cockayne extended the boundaries of his Marlborough-Sounds Subdistrict southwards and westwards, and changed the name to "Sounds-Wairau." As defined by that author, the area was bounded on the south by the River Wairau, and on the west by the average limit of the westerly rainfall. Although this area in that portion of its coastal-lowland-montane belt exposed to a forest-climate may rightly be united to the North Island part of the Ruahine-Cook Botanical District, yet its mountainous portion above the forest-line is markedly different, containing as it does so many species absent on the Ruahine-Tararua Range. It seems to us better, then, to raise it to the rank of a botanical district, under the name "Sounds-Nelson." Even when this is done there are three distinct sections- (1) the former Marlborough Sounds Subdistrict; (2) the area lying westwards and southwards of Nelson City between the mountains (Ben Nevis, Gordon's Nob, &c.) and Tasman Bay, extending to the western boundary; and (3) the high mountains as a whole.

This separation of the South Island portion of the Ruahine-Cook Botanical District raises the North Island part to the rank of a district, to which we apply the name "Ruahine-Cook." Thus the North and South Islands are kept distinct floristically and ecologically.

The flora of the Sounds-Nelson Botanical District is marked by a fairly high degree of local endemism, as shown by the following list:—

GRAMINEAE.—*Poa acicularifolia*—a variety probably confined to the Mineral Belt; *Festuca*—a species possibly confined to the Mineral Belt.

RANUNCULACEAE.—*Clematis parviflora* var. *depauperata*—given on the authority of *Man. N.Z. Flora*, but we know nothing about it.

CRUCIFERAE.—*Notothlaspi australe* var. *stellatum*.

LEGUMINOSAE.—Probably an undescribed species of *Carmichaelia*—grows in the Rai and Pelorus Valleys, the stems extremely slender, the flowers small.

EUPHORBIACEAE.—*Poranthera microphylla*.

THYMELAEACEAE.—*Pimelea Suteri*.

BORAGINACEAE.—*Myosotis Monroi*.

LABIATAE.—*Scutellaria novae-zelandiae*.

SCROPHULARIACEAE.— × *Hebe Simmonsii* Ckn. et Allan comb. nov. = × *Veronica Simmonsii* Ckn. in *Trans. N.Z. Inst.*, vol. 48, 1916, p. 202; *H. rigidula* Ckn. et Allan comb. nov. = *Veronica rigidula* Cheesem. in *Man. N.Z. Flora*, 1906, p. 514; *H. divaricata* Ckn. et Allan sp. nov. = *Veronica Menziesii* Benth. var. *divaricata* Cheesem. in *Man. N.Z. Flora*, 1906, p. 512; *H. Gibbsii* Ckn. et Allan comb. nov. = *Veronica Gibbsii* T. Kirk in *Trans. N.Z. Inst.*, vol. 28, 1896, p. 524.

COMPOSITAE.—*Olearia serpentina* Ckn. et Allan sp. nov. ined.—Common on the Mineral Belt at all altitudes; *Celmisia Rutlandii*, *C. cordatifolia*, *C. Macmahoni*; *Raoulia Gibbsii*; *Cassinia Vauvilliersii* (Homb. et Jacq.) Hook. f. var. *serpentina* Ckn. et Allan.

With regard to the vegetation, that of the northern and eastern portions of the district in the coastal-lowland-montane belt has a plant-covering similar to that of the southern part of the Ruahine-Cook Botanical District. Thus the lowland forest is taxad or *Beilschmiedia tawa* rain-forest on the better ground, and *Nothofagus truncata* - *N. Solandri* forest in exposed positions or where the soil is poorest, while near the sea there is on the most fertile soil *Dysoxylum spectabile* coastal - forest.

On coastal rocks *Arthropodium cirratum* (absent in Ruahine - Cook), *Phormium Colensoi*, *Astelia Solandri*, and *Griselinia lucida* are characteristic. *Digitalis purpurea*, *Rubus fruticosus* (agg.), and the indigenous *Cassinia leptophylla* are common weeds which form pure associations. Dairy-farming is carried on in the fertile valleys on artificial meadows which replace rain-forest proper.

In the lowland-montane area southwards and westwards from Nelson City, which is the driest part of the district, there are wide stretches of *Leptospermum scoparium*, mostly induced. In places this has been replaced by orchards. The hills are occupied by *Leptospermum scoparium*, *Pteridium esculentum*, or *Danthonia pilosa* grassland. As the western boundary of the district is approached *Nothofagus* forest again puts in an appearance with the addition of *N. fusca* and *N. Menziesii*. Where forest extends, or did originally extend, continuously from the North-western District to the Sounds-Nelson, it is not easy to decide to which of the two it belongs, but certain forest species are peculiarly North-western—*e.g.*, *Podocarpus acutifolius*, *Dracophyllum latifolum*, and *Senecio Hectori*.

The Mineral Belt is a striking feature of the district. It extends south-west from D'Urville Island for a distance of about sixty miles, and is clearly marked out from the forest by its stunted vegetation, due probably to excess of magnesia in the soil. It is usually quite narrow, being in one part barely 100 yards wide, but its widest part, on the flanks of the Dun Mountain, is more than three miles across. It occurs from sea-level to the subalpine belt, its plant-covering changing considerably with increase of altitude.

The subalpine flora of the district is rich in species, since near its western boundary it has, in addition to its flora proper, a good many species in common with the adjacent North-western District. Much of the high-mountain area is insufficiently explored botanically, so we can give no details of real value.

Notes on New Zealand Floristic Botany, including Descriptions of New Species, &c. (No. 4).

By L. COCKAYNE, Ph.D., F.L.S., F.R.S., F.N.Z.Inst., and H. H. ALLAN, M.A., D.Sc., F.L.S.

[*Read before the Wellington Philosophical Society, 27th August, 1924; received by Editor, 31st December, 1924; issued separately, 6th March, 1926.*]

44.* Acaena microphylla × Sanguisorbae.

A few seeds were sown in 1923 by L. C. of a supposed hybrid as above collected by him in the Dart Valley (Fiord Botanical District). The seed germinated well, and the seedlings betray their hybrid origin in the colour of the leaves (brown, pale green, darker green, slate-colour, &c.) and the size and shape of the leaflets. So far none have flowered. It is possible that one of the parents may be *Acaena inermis*, while it is not possible to say what particular variety of *A. Sanguisorbae* was the other parent.

45. Acaena Sanguisorbae Vahl. var. **sericei-nitens** Bitter.

This is the common upland *Acaena* of the South Otago Botanical District, and it extends into the adjacent part of the Fiord Botanical District. Seed collected by L. C. in the neighbourhood of Lake Wakatipu in 1923 has produced a number of seedlings most closely resembling one another, showing that the variety is a true microspecies (Jordanon).

46. Astelia nervosa Banks et Sol. ex Hook. f.

This aggregate species includes several distinct varieties. We here segregate the broad-leaved lowland swamp-plant with stout male inflorescence from the common narrow-leaved forest-plant with slender male inflorescence. The former has been given specific rank as *A. grandis* by Kirk (*Trans. N.Z. Inst.*, vol. 4, p. 245, 1872), but it seems better to retain it in the aggregate. We thus have—

(*a.*) *Astelia nervosa* Banks et Sol. ex Hook. f. var. *grandis* (Hook. f. ex T. Kirk) Ckn.† et Allan comb. nov.

(*b.*) *Astelia nervosa* Banks et Sol. ex Hook. f. var. *sylvestris* Ckn. et Allan var. nov.

Varietas distincta foliis plerumque ± 1·6 m. longis, interdum valde longioribus, ± 5 cm. latis, anguste linearo-lanceolatis attenuatis; paniculis masculis gracilibus ± 40 cm. longis.

47. Carmichaelia australis R. Br. var. **egmontiana** Ckn. et Allan var. nov.

Ramulis angustis applanatis ± 3 mm. latis; racemis circiter 5-floris.

North Island: Egmont-Wanganui Botanical District — Common as a member of the subalpine scrub on Mount Egmont.

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* The numbers follow on consecutively in this series of papers.

† The abbreviation we are using for "L. Cockayne."

This variety is at once distinguished by its narrow branches and branchlets from the more widely-spread forms with comparatively broad branchlets. An examination of the type specimens of Kirk's var. *strictissima* showed that our plant is quite distinct in its much narrower branchlets, its spreading few-flowered racemes. The flowers of var. *egmontiana* are small, the standard being dark purple flanked by purple lines, and shading to a white margin. A seedling plant of var. *egmontiana* examined had the petioles and leaves on both surfaces sparsely clothed with short hairs. The leaves were pinnately 3–5-foliate, with leaflets ± 8 mm. long, broadly obovate, sessile.

48. **Cassinia Vauvilliersii** (Homb. et Jacq.) Hook. f. var. **serpentina** Ckn. et Allan var. nov.

Folia minora, laminis circa 4 mm. longis infra pallide brunneis haud fulvis, costis minus carinatis; inflorescentia valde parviora ± 1·5 cm. diam., capitulis ± 20, circa 5 mm. longis.

South Island: Sounds-Nelson Botanical District—On Mineral Belt of the Dun Mountain: L. C.

Distinguished from *C. albida* (T. Kirk) Ckn. by the colour of the tomentum and the much smaller leaves. It might quite well be thought an epharmonic form of *C. Vauvilliersii*, due to the magnesian soil, but, if so, it is apparently "fixed," as it has kept unchanged to any extent for five years in cultivation.

49. **Coprosma Petriei** Cheesem.

There are two varieties* of this species, distinguished by the colour of the drupes.

(*a.*) *Coprosma Petriei* Cheesem. var. *vera* Ckn. et Allan var. nov.

This is the type, described by Cheeseman (*Trans. N.Z. Inst.*, vol. 18, p. 316, 1886). He states that the drupes are "bluish," but perhaps it is more accurate to describe them as translucent, faintly stained very pale blue.

(*b.*) *Coprosma Petriei* Cheesem. var. *atropurpurea* Ckn. et Allan var. nov.

A typo drupis atropurpureis differt.

In this variety the drupes are much the colour of port-wine. The two varieties often grow side by side, but usually in pure patches of considerable size. They do not seem to hybridize. We have noted both varieties in various parts of the North-eastern and the Eastern Botanical Districts. Evidently each variety comes true from seed.

50. **Epilobium melanocaulon** Hook.

Two well-marked varieties constantly occur side by side on stony river-beds throughout the range of the species. Possibly the two varieties cross, but we have no notes on the matter.

(*a.*) *Epilobium melanocaulon* Hook. var. *viride* Ckn. et Allan var. nov.

Caulibus foliisque griseo-viridibus.

(*b.*) *Epilobium melanocaulon* Hook. var. *typica* Ckn. et Allan var. nov.

Caulibus intense atropurpureis paene nigris foliis atrorubris.

This variety is by far the more common.

* Since the descriptions were drawn up L. C. has seen a variety near Cass with white flowers.

51. **Epilobium pernitens** Ckn. et Allan sp. nov.

Herba parva, prostrata, affinis *E. peduncularis* A. Cunn. sed foliis floribusque valde distincta. Caules procumbentes radicantes saepe conferti. Folia maxime nitentia, viridia, interdum purpurascentes, convexo-concava, satis crassa, rotunda ± 6 mm. diam. vel subrotunda, marginibus paulo recurvatis. Petioli brevissimi sed distincti. Flores non multi, ut apparet, maiusculi, usque ad 16 mm. diam., axillares. Pedunculi ± 5 cm. longi, graciles, arrecti, roseo-brunnei. Calycis-lobi oblongo-lanceolati, acuti, ± 4 mm. longi, pallide virides vel rubentes. Petala alba, late obovata, ± 8 mm. longa, apice valde emarginata, ± 10 atris lineis ornata. Capsuli ± 3·1 cm. longi, glabri, pedunculis in fructu ± 5·3 cm. longis.

North Island: Ruahine-Cook Botanical District—Ruahine Mountains, Tararua Mountains, in subalpine herb-field on margins of bare places: H. H. A. South Island: North-western Botanical District – Paparoa Mountains: L. C.

This beautiful little species is distinguished at once from its nearest relatives—*E. nummularifolium*, *E. pedunculare*, and *E. nerterioides*—by its extremely glossy, convex, very small, rotund or subrotund leaves and its comparatively large flowers. It is to be recommended for the alpine garden, as its small patches of glistening foliage and large white flowers remind one somewhat of *Linnaea borealis*. It sows itself abundantly, but is not likely to become a garden-weed.

52. **Gaya Allanii** Ckn. sp. nov.

Arbuscula circa 4·5 m. alta; ramuli iuventute striati, plerumque stellato-pubescentes, demum glabrati, cortice griseo-brunneo obtecti. Folia

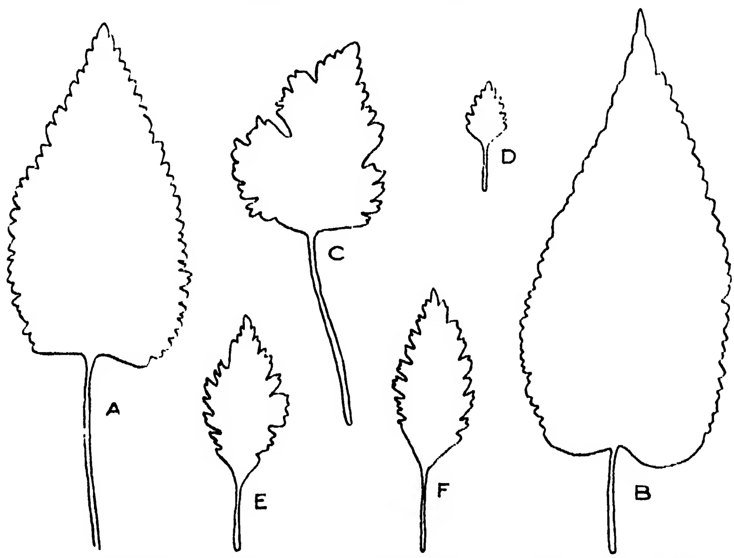

FIG. 1.—Leaves of *Gaya*: A, *G. ribifolia* Mount Fyffe; B, *G. Lyallii*; C, *G. ribifolia*, Mount Torlesse; D, *G. Allanii*, juvenile; E, F, *G. Allanii*, adult. × ½.

juvenilia ± 1·5 cm. longa, ± 8 mm. lata, petiolis ± 5 mm. longis, ovata, crenato-serrata, acuta, sparsis stellatis pilis induta. Folia

matura ± 5 cm. longa, ± 2 cm. lata, ovato-lanceolata, basi cuneata, submembranacea, grosse et incise bi-serrata vel crenato-serrata, pallide viridia, subtus pallidiora, acuta, supra et infra sparsis pilis stellatis albis brevibus plus minusve deciduis induta, nervis subconspicuis. Petioli graciles ± 1·5 cm. longi, stellatis pilis vestiti, canaliculati. Flores 3–5 fasciculati, brevium ramulorum apicibus versus vel axillares. Pedunculi graciles, ± 1·5 cm. longi, stellato-pubescentes. Calyx late campanulatus, 5-lobatus, dense stellato-pubescens, lobis acute triangulariis, ± 4 mm. longis. Petala ± 1·5 cm. longa, ± 7 mm. lata, oblique obovata, obtusa, retusa, unguiculata, infra satis dense stellato-pubescentia supra glabrata. Columna staminea brevis, basi distensa; filamenta gracilia ± 6 mm. longa, glabra; antherae ± 30. Ovarium ovoideum, ± 4 mm. longum, ± 2 mm. diam., plerumque 7-, interdum 6- vel 8-loculatum, loculis compressis, stellatis pilis vestitis.

South Island: Eastern Botanical District—Peel Forest, on margin of taxad forest: H. H. A. Flowers in January.

This very distinct species differs markedly in its smaller, differently shaped leaves, and rather smaller flowers with fewer carpels, from either of the other two species of the genus. Superficially it bears a much closer resemblance to *Hoheria sexstylosa.* It will some day become a famous garden-plant and take its place alongside the justly famed mountain-ribbonwood, *G. Lyallii.* It will be easily raised from seed, and probably from cuttings. Fig. 1 shows outlines of juvenile (D) and adult (E, F) leaves of *Gaya Allanii*, and of leaves from flowering specimens of *G. Lyallii* (B, Kelly's Hill, Westland) and *G. ribifolia* (A, Mount Fyffe, Seaward Kaikouras; C, Mount Torlesse, Canterbury).

53. Hebe as a Genus to replace a certain Section of *Veronica.*

F. W. Pennell (*Rhodora*, vol. 23, pp. 1–22 and 29–41, 1921; reprinted as *Contrib. N.Y. Bot. Garden*, No. 230, 1921) has restored Commerson's genus *Hebe* (Juss., *Gen. Pl.*, 105, 1789). *Hebe*, as defined by Pennell, includes all those shrubs and trees hitherto referred to *Veronica* which occur in New Zealand, subantarctic South America, the Falkland Islands, Tasmania, and south-east Australia. The distinctions between *Hebe* and *Veronica* are as follows: the capsule dehisces septicidally (not loculicidally), the thick (not thin) septum splitting and each carpel opening distally by a median slit through the septal wall; the leaves are always opposite and after falling leave more or less conspicuous scars; the flowers are usually in axillary racemes, but these may be greatly reduced, spicate or corymbose; and all are evergreen shrubs, or in a few cases trees. Pennell remarks, "The austral distribution, with its suggestion of genetic remoteness, emphasizes *Hebe's* claim to recognition as a genus." It is, indeed, the restriction of the group to those portions of the temperate Southern Hemisphere already noted, together with the evergreen, shrubby habit of its members, which so markedly separates *Hebe* from *Veronica* proper, that has induced us to support Pennell's action. *Hebe* thus becomes of great phytogeographical significance. Pennell also points out that "*Hebe* has an exceedingly baffling tendency to form local races, a habit at contrast with that of the other 'Veronicas.'"

Now, L. C., at any rate, has long been of opinion that the section *Hebe* of *Veronica* should be raised to generic rank. Therefore, as soon as Pennell's paper came into his hands, he sent it to the late Mr. T. F. Cheeseman, and wrote on the matter to Professor Dr. L. Diels and

Dr. C. Skottsberg, whose opinion on any subject concerning subantarctic botany must receive the most careful consideration. Cheeseman replied that Pennell's action was probably justified, but that, as in the new edition of his *Flora* the genus *Veronica* was çompleted, he did not intend to make any alteration, and that in the absence of any other systematist of note having dealt with the question he had in the first edition followed Wettstein's treatment in *Die Pflanzenfamilien*. That a botanist so conservative as Cheeseman should consider the change to *Hebe* as probably correct speaks strongly in favour of the alteration.

Diels considered the change might quite well be made, and pointed out how certain genera had been removed from the wide conception of *Veronica*, which were closer to that genus than was *Hebe*. Skottsberg, though in general considering that there is in certain quarters a tendency to greatly overdo the splitting-up of genera, thought that the case of *Hebe* was in another category owing to its strictly limited distribution. In New Zealand, in addition to ourselves, Mr. W. R. B. Oliver has decided *Hebe* must stand, and has adopted the genus in a recently written paper.

The two objections to the change are that it will be very slowly adopted in horticulture and with more or less inconvenience, and that over one hundred species will have to be transferred. Fortunately, this will very rarely lead to changes in specific names. The following changes have already been published or are in course of publication: *H. blanda* (Cheesem.) Pennell, *H. buxifolia* (Benth.) Ckn., *H. elliptica* (Forst. f.) Pennell, *H. salicifolia* (Forst. f.) Pennell, *H. subalpina* Ckn., *H. vernicosa* (Hook. f.) Ckn.

54. **Hebe Allanii** Ckn. sp. nov.

Frutex parvus, circa 30 cm. altus, ramulis patulis, profunde cicatricibus foliorum delapsorum notatis; internodia ± 8 mm. longa, dense albis pilis pubescentia. Folia sessilia, patentia vel retroflexa, paene subcordata, ± 1·8 cm. longa, ± 8 mm. lata, oblonga, subacuta, dense supra et infra pubescentes, marginibus ciliatis interdum rubro-tinctis, coriacea, glauca, paulo incurvata; costa inconspicua. Folia subfloralia ± 1·1 cm. lata, ovata vel obovato-oblonga. Spicae ± 25 florae, breves, paucae, axillares apicem ramulorum versus; pedunculi usque ad 2·5 cm. longi, dense mollibus patulis pilis albis induti. Flores sessiles, conferti. Bracteolae ± 5 mm. longae leviter carinatae, ovatae, subacutae vel obtusae, pubescentes, calyce paululum breviorae. Calyx pubescens ± 5 mm. longus; lobi profunde incisi, ovati, obtusi vel subacuti, pallide virides, marginibus scariosis. Corolla alba; tubus ± 6 mm. longus, calycis lobos excedens, extra sparsis pilis ornatus infra glaber; lobi patuli, ± 6 mm. longi, basim versus pilis sparsis infra ornati, ovati vel ovato-oblongi, obtusi. Stamina exserta, antheris atropurpureis. Ovarium pubescens. Capsula adhuc non visa.

South Island: Eastern Botanical District—On rocky outcrops in tall tussock-grassland at about 360 m., Mount Peel: H. H. A.

This well-marked species comes nearest to *Hebe amplexicaulis*, but is separated at once by its shorter branches, its leaves closely covered with hairs on both surfaces and with ciliate margins, its smaller, denser inflorescences, and smaller flowers, which are hairy in all parts except the upper portions of the corolla-lobes. It may easily be mistaken for *H. Gibbsii* on account of the presence of hairs on the leaves, calyx, &c., but in the latter species the leaves are ciliated only, and the calyx-lobes

are much narrower and sharply acute. Although *Hebe* is so richly represented in gardens, a species so distinct and striking as *H. Allanii* is certainly a great acquisition. It is easily raised from cuttings and from seed, and will probably grow in poor soil in almost any situation.

55. Hebe amplexicaulis (J. B. Armstg.) Ckn. et Allan comb. nov.

This species was first described by Armstrong (*N.Z. Country Jour.*, vol. 3, p. 56, 1879) from a plant collected in the upper Rangitata by J. F. Armstrong. This (given in the description as "decumbent") is the well-known almost prostrate garden-plant, which is to be taken as the type of the species, and which is here given the varietal name *vera*. The species was again described by Armstrong in 1881 (*Trans. N.Z. Inst.*, vol. 13, p. 352), a plant collected in the upper Waiau, Nelson, being included in the conception of the species. The words "or suberect" are added to the habit description. Cheeseman's description (*Manual N.Z. Flora*, p. 525, 1906) differs from the original in stating the corolla-tube to be "about the length of the calyx," and he remarks, "Mr. Armstrong describes the corolla-tube as long, but it barely equals the calyx in all the specimens I have seen, including an authentic one from him."

Our observations in the field and in the garden show that *H. amplexicaulis* is an aggregate allied to the group that includes *H. albicans* (Petrie), but differing in the more obtuse semi-amplexical leaves, and the spicate not racemose inflorescences, with larger obtuse bracteoles. We find the corolla-tube of *H. amplexicaulis* distinctly longer than the calyx, but this is not shown till the flower has fully developed, so that young inflorescences may have the flowers as described by Cheeseman. Although the floral characters are very similar in all, we consider the habit differences sufficient to mark off the following varieties: -

(*a.*) *Hebe amplexicaulis* (J. B. Armstg.) Ckn. et Allan var. *vera* Ckn. et Allan var. nov.

This is the type, and needs no further description.

(*b.*) *Hebe amplexicaulis* (J. B. Armstg.) Ckn. et Allan var. *suberecta* Ckn. et Allan var. nov.

Caules non multi, pauciramosi: rami primo decumbentes deinde ascendentes, patuli, nudi; ramuli ultimi suberecti deorsum nudi, sursum foliis confertis obtecti; spicae breves floribus confertis.

South Island: Eastern Botanical District—A rock-plant from about 340 m. to 1,200 m., Mount Peel, abundant: H. H. A.

Distinguished from var. *vera* by its open straggling habit, with long naked branches ending in suberect branchlets with crowded leaves. In cultivation it becomes of denser, less rambling habit.

(*c.*) *Hebe amplexicaulis* (J. B. Armstg.) Ckn. et Allan var. *erecta* Ckn. et Allan var. nov.

Caules numerosi, erecti, ramosi; ramuli ultimi stricti, deorsum nudi, sursum foliis confertis obtecti; spicae longiores floribus numerosis.

South Island: Eastern Botanical District—On rocky outcrops at about 350 m. altitude, upper Rangitata River: H. H. A.

Only a few plants of this very distinct erect bushy variety were seen. The spikes are longer with less crowded flowers than in var. *suberecta*, and are more abundantly produced, so that the shrub presents a handsome appearance when in flower.

56. Hebe buxifolia (Benth.) Ckn. var. **pauciramosa** Ckn. et Allan var. nov.

Rami ultimi pauci, arrecti, foliis brevibus patentibus dense obtecti.

South Island: North-western, Western, Fiord, and South Otago Botanical Districts. In wet ground, mainly subalpine: L. C.

Hebe buxifolia is an aggregate species embracing many forms, but all distinguished by the smooth, glossy, green, keeled leaves, with short but distinct petioles (seedling and reversion leaves are deeply toothed or subpinnate), the short spikes of flowers more or less aggregated into heads, and the large bracteoles much resembling ordinary leaves. There are many intergrading forms extremely difficult to classify, but a knowledge of the species throughout its range shows that there are several well-marked varieties, which almost certainly hybridize, so producing the remarkable polymorphy. The varieties so far described are (*a*) var. *prostrata*, which more or less closely hugs the ground; (*b*) var. *odora*, much-branched, eventually forming a globose bush; and (*c*) var. *pauciramosa*, here discussed. This last, possibly itself an aggregate, is distinguished by its erect final branches (it may be more or less prostrate at the base), straight, erect stems, leafy only in their upper portions, which branch but little and form a shrub of open habit. We have under observation other apparently distinct varieties, but they require further investigation.

57. Hebe Treadwellii Ckn. et Allan sp. nov.

Frutex humulis, ramulis elongatis, depressis, dispersis, cortice pallide brunneo obtectis, inferne cicatricibus foliorum delapsorum notatis. Folia arte imbricata, ± 2·5 cm. longa, ± 1·2 cm. lata, obovato-oblonga, subacuta, fere sessilia, supra valde concava, infra convexa, glabra, crassa, coriacea, satis nitentia, pallide viridia, marginibus pallidioribus; costa depressa. Petioli brevissimi applanati. Racemi duplices in foliorum superiorum axillis positi, aliquanto foliis obscurati, ± 1·2 cm. longi, pauci-flori; pedunculi, rhaches et bracteae (marginem versus) minute pubescentes. Bracteolae subulatae, calyce breviores. Flores albi, parvi, superiori sessiles, inferiori breviter pedicellati. Calyx 4-segmentatus; segmenta ovata, acuta, tubo corollae breviora, pallide viridia, marginibus ciliatis. Corollae tubus brevissimus, latus, calycem aequans; limbus 4-lobatus, haud patulus, lobis obtusis. Ovarium et stigma glabrum. Capsula non visa.

South Island: Western Botanical District. On stony ground at about 1,200 m. on Mount Ollivier (Sealy Range), and near the Mueller Glacier at a similar altitude: L. C.

This species, probably a common plant within its range, comes into the group which contains *Hebe pinguifolia* and its allies, but it is distinguished by its green leaves, its fewer few-flowered racemes almost hidden by the leaves, its subulate bracteoles, its smaller flowers with acute calyx-segments, and its glabrous ovaries and stigmas.

58. Metrosideros perforata (Forst.) A. Rich. = *M. scandens* Sol. ex Gaertn.

The specific name given by the Forsters (*Characteres Generum*, p. 72, 1776) was the first valid one, and Richard's adoption of it (*Essai d'une Flore de la Nouvelle-Zélande*, p. 334, 1832) must be followed.

59. **Myosotis Colensoi** (T. Kirk) Ckn. et Allan comb. nov. = *M. decora* T. Kirk ex Cheesem.

Exarrhena saxosa Hook. f. was described by Hooker (*Fl. Nov.-Zel.*, i, 202) from a plant collected by Colenso in the North Island at Titiokura. In the *Handbook* (p. 196) he united with it a plant from the Dun Mountain, Nelson, collected by Monro and Travers. Kirk (*Trans. N.Z. Inst.*, vol. 27, p. 351, 1895) described a plant from limestone rocks at Broken River, Canterbury, collected by Enys and himself, as *E. Colensoi*, and united with it the Titiokura plant, saying, "A remarkable plant which has hitherto been confused with the Nelson *E. saxosa* Hook. f." But, as *E. saxosa* is based upon the Titiokura plant and not the Nelson one, Cheeseman appears to have adopted a suggestion of Kirk to rename the Broken Hill plant as *Myosotis decora* (*Manual*, p. 462, 1906), the Nelson plant receiving the name *M. Monroi* (*ibid.*, p. 469). But, since the Broken Hill plant provided the material for Kirk's original description of his *E. Colensoi*, that specific name should be adopted.

60. **Nothopanax arboreum × Pseudopanax crassifolium var. unifoliolatum.**

Mr. E. Phillips Turner recently discovered on Kapiti Island, growing amongst *Leptospermum ericoides*, what he thought to be the above hybrid. In this conclusion we are strongly inclined to concur. The plants, three in number, were growing side by side close to a young plant of *P. crassifolium* var. *unifoliolatum*. From the largest plant, some 40 cm. tall, Mr. Turner collected four leaves. Fig. 2 should give a sufficient idea of the leaf-form and size. Except B, the leaves differ greatly from

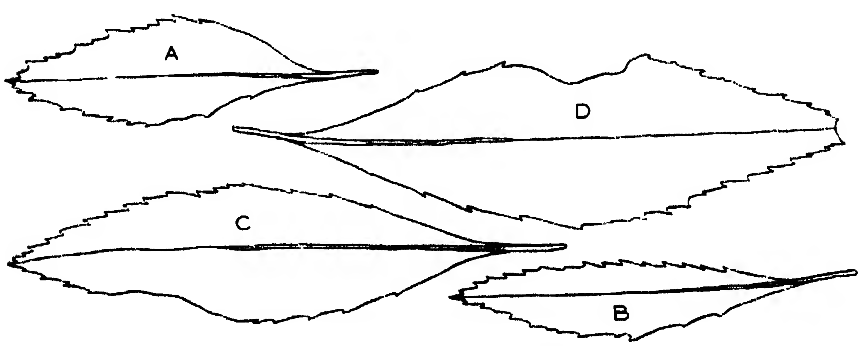

Fig. 2.—Leaves of *Nothopanax arboreum* × *Pseudopanax crassifolium* var. *unifoliolatum*. × ½.

those of any stage of the polymorphic *P. crassifolium*. The excessive increase in breadth is what might be expected from a cross with *N. arboreum*. The texture is similar to that of *N. arboreum*, and the venation with the secondary veins diverging at angle of about 50° is that of *N. arboreum*, the angle in the case of *P. crassifolium* being about 20°. The midribs are prominent above and below, as in juvenile *P. crassifolium*, and the marginal teething is nearer that of *P. crassifolium* than of *N. arboreum*. The base of the lamina is intermediate in form.

61. Nothopanax parvum (T. Kirk) Ckn.

L. Cockayne* recently expressed the opinion that *Nothopanax parvum* = *N. anomalum* × *simplex*. This view is supported by a number of specimens of what was apparently *N. parvum* studied by him in the Spey Valley, west of Lake Manapouri. Unfortunately, too few specimens were collected, but they were present in great numbers and made up a

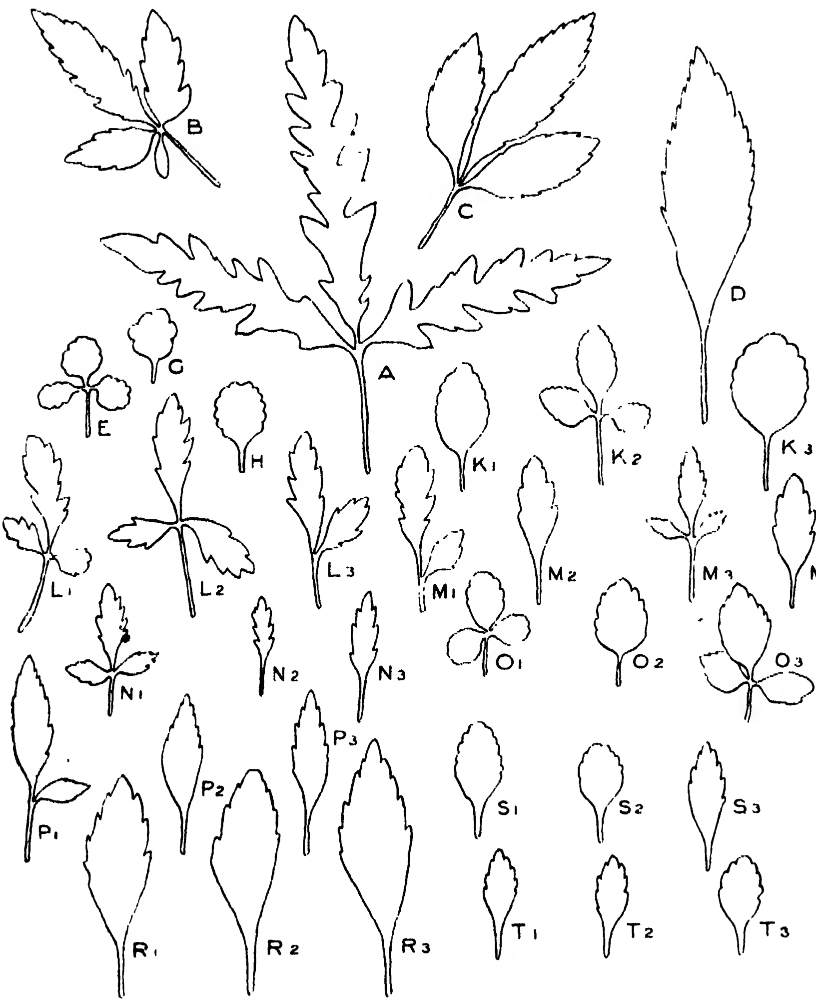

FIG. 3.—Leaves of *Nothopanax simplex*, *N. anomalum*, and *N. parvum*. × ½.

most polymorphic group. These juvenile plants differ greatly from those of the supposed parents, but exhibit features which certainly suggest a mixture of parental characters. *N. simplex* has juvenile leaves ovate-serrate or 3–5-foliolate with the leaflets deeply cut (fig. 3, A—a small

* See L. COCKAYNE, Hybridism in the New Zealand Flora, *The New Phytol.*, vol. 22, No. 3, p. 126, 1923.

example). These are succeeded by 3-foliolate leaves with the leaflets lanceolate-serrate (fig. 3, B, C). The adult has simple lanceolate-serrate leaves (fig. 3, D). It is almost certain that there are distinct races differing in their juvenile stages. *N. anomalum* has small 3-foliolate juvenile leaves with leaflets elliptic-ovate or rounded-ovate with crenate margins (fig. 3, E), succeeded by simple adult leaves oblong-orbicular, crenate-toothed (fig. 3, G, H). The leaves of the Spey Valley juveniles show intermediate characters, as can be seen from the drawings of three specimens (fig. 3, K1, K2, K3; L1, L2, L3; M1, M2, M3, M4). Two juveniles from Stewart Island are figured (fig. 3, N1, N2, N3; O1, O2, O3) which also show an intermingling of parental characters. Adult flowering specimens are figured from Inchbonnie, Westland (fig. 3, P1, P2, P3), and Stewart Island (fig. 3, R1, R2, R3; S1, S2, S3; T1, T2, T3). An examination of the drawings, traced from nature-prints, will be sufficient to show the intricate way in which the various parental characters are intermingled, without the necessity of drawing up an elaborate table. That flowering should occur on forms so different as P, R, S, T is important evidence as to their hybrid origin. This is borne out by the intermediate character of the inflorescences, bridging the gap between the few-flowered simple umbels of *N. anomalum* and the comparatively large compound umbels of *N. simplex.*

62. **Ourisia Macphersonii** Ckn. et Allan sp. nov.

Herba perennis, rhizomatis longis ± 8 mm. diam. Folia radicalia subcoriacea. Laminae ± 4·5 cm. longae, ± 3·5 cm. latae, supra pilis mollibus sparsis vestitae, infra glabratae, ovatae vel ovato-oblongae, apice obtusae, basi subcordata vel cuneatae, marginibus crenatis vel crenato-serratis, ciliatis; subtus purpuratae, venis viridibus distincte reticulatae. Petioli ± 3·5 cm. longi, striati, sparsis albis pilis induti, vaginantes, bases versus latescentes. Inflorescentia maiuscula; rhachis ± 30 cm. longus, basi ± 1 cm. diam., erectus, nervatus, pilis brevibus vestitus, interdum purpurascens, plerumque 5-verticillatus, verticillis sursum deminuentibus in omnibus partibus. Bracteae verticillatae, plerumque 5 per verticillum: inferiorae breviter petiolatae, late lanceolatae vel lanceolato-oblongae, obtusae, crenato-serratae vel crenatae; superiorae oblongae, obtusae, sessiles. Flores 7–8 per verticillum. Pedicelli ± 4 cm. longi, patuli, paulo crassi, albis pilis vestiti. Calycis-lobi usque ad basim 5-partiti, extra pilosi; lobis oblongis vel obovatis, apice purpuratis, obtusis vel subacutis, marginibus ciliatis, venis purpuratis distinctis. Corollae ± 2·5 cm. diam., albae, in fauces luteae glandulosis pilis ornatae; tubi ± 6 mm. longi, 2 inferiori lobi subrotundi vel late oblongi, patentes; 3 superiori lobi obovato-oblongi, suberecti, 3–4 venis distinctis, apice rotundati vel prope truncati. Stamina 4, supra apicem corallae tubi paulo exserta; antherae cremeae, reniformes. Styli longi, graciles, papillati, stigmatis 2-lobatis. Capsula paulo compressa, ± 1 cm. longa, ± 5 mm. lata, mucronata, calyce persistente induta.

South Island: Fiord Botanical District—Shady banks of River Spey at about 210 m., and in open boggy ground towards Wilmot Pass at 670 m. altitude: L. C.

This species has affinities with *Ourisia macrophylla* Hook. and *O. Colensoi* Hook. f., but differs from the former in the rather thicker, smaller leaves, the absence of cauline leaves, the lower bracts lanceolate petiolate (not linear-oblong), the yellow-throated flowers, the oblong or obovate (not

lanceolate or linear) calyx-lobes, and the rather larger hardly turgid capsules. From *O. Colensoi* it is at once distinguished by the stouter habit, bracts in whorls of ± 5 (not paired), more numerous larger flowers on longer petioles, in whorls of 7–8, and the calyx-lobes not linear.

The plant blooms for about two months, commencing under cultivation near Wellington in the middle of October, and continuing until the second week of December. It appears to be of easy cultivation, and in the southern rainy parts of New Zealand should grow with the greatest vigour. The tiers of large white flowers with yellow throats, one above another after the manner of *Primula japonica*, make it a most effective plant for the alpine garden. It will not tolerate drought.

63. Plagianthus cymosus T. Kirk.

This so-called species invariably grows along the banks of tidal rivers not far from the sea where *P. betulinus* and *P. divaricatus* grow near one another. Mr. W. Martin, B.Sc., has recently collected

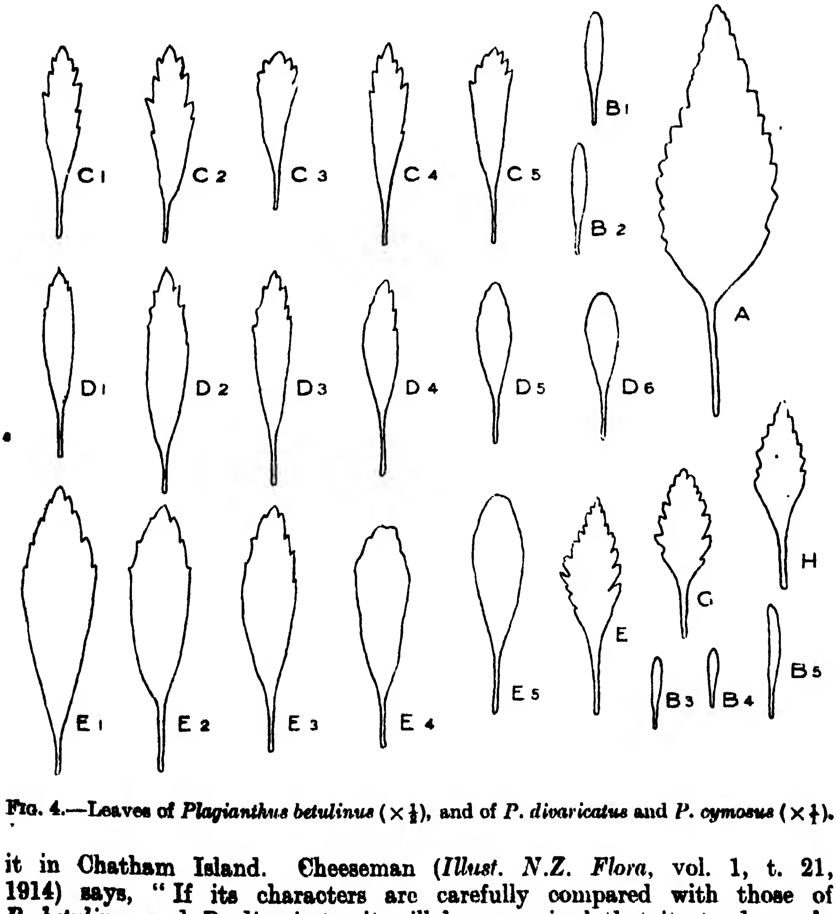

FIG. 4.—Leaves of *Plagianthus betulinus* (× ½), and of *P. divaricatus* and *P. cymosus* (× ⅟).

it in Chatham Island. Cheeseman (*Illust. N.Z. Flora*, vol. 1, t. 21, 1914) says, "If its characters are carefully compared with those of *P. betulinus* and *P. divaricatus* it will be recognized that it stands nearly half-way between the two species. The suspicion of a hybrid origin at

once arises, and it must be confessed that such an assumption would go far towards explaining the peculiar rarity of the plant in some of its localities. On the other hand, fruiting specimens sent to me by Mr. H. J. Matthews from the Pelorus Valley have well-developed and well-ripened seeds with a fully developed embryo, and show no signs of the impaired fertility frequently seen in hybrids." L. Cockayne, in the *New Phytol.* paper already cited, listed it as a probable hybrid, the case of which required further investigation. In view of the number of hybrids now known to produce fertile seed, Cheeseman's objection does not seem to have any weight.

We have examined specimens from several localities—Pelorus Valley, Kaitaia, Chatham Island—and the leaf-characters strongly suggest a hybrid origin. *P. divaricatus* (fig. 4, B1, B2, B3, B4, B5) has small linear obtuse leaves, quite entire, while *P. betulinus* has large ovate-lanceolate crenate-serrate leaves, acute, with more or less cuneate bases (fig. 4, A). Representative leaves taken from single shoots from each locality well show the mingling of parental characters, in their intermediate size and inconstant shape and toothing—Kaitaia specimen (fig. 4, C1, C2, C3, C4, C5); Pelorus River specimens (fig. 4, D1, D2, D3, and D4, D5, D6); Chatham Island specimen (fig. 4, E1, E2, E3, E4, E5). These should be compared with the figures given in *Illustrations of the N.Z. Flora* from specimens collected in the Pelorus Valley, which show still another somewhat different form. Leaves taken from among the inflorescences of herbarium specimens of *P. betulinus* are also shown (fig. 4, E, G, H). These show a reduction in size but retain the characters of *P. betulinus*, and it is to be remembered that in this species the leaves are not fully developed at flowering-time. *P. divaricatus* has flowers solitary or in few-flowered fascicles, while *P. betulinus* has numerous flowers in large panicles. Our Kaitaia specimen has small male panicles just as might be anticipated on the hybrid theory, while, according to Mr. Martin, in the Chatham Island plant the fruit-clusters never exceed four. The number of anthers in our Kaitaia specimen is about 15–20 per flower. There can hardly be any doubt that *P. cymosus* is a hybrid with the parentage suggested.*

64. **Pterostylis confertifolia** Allan sp. nov.

Herba terrestris glabra, ± 7 cm. alta; erecto caule e tubere pisiforme ± 7 mm. diam. Folia conferta caulem amplectantia, inferiora scariosa squamiforma, obtusa, superiora plerumque 3, erecto-patentes, pallide viridia, paulo crassa, in siccitate tenuiora; laminae 3–5 cm. longae, 1·5–2 cm. latae, elliptico-ovatae, obtusae, venis per vitam obscuris, marginibus paulo incurvatis, basim versus in vaginas latas albas angustatae. Flores solitarii, virides, venis rubris, vix folia excedentes, aliquanto in fructu increscentes, ± 2 cm. longi, ovario obovoideo ± 1·5 cm. longo excepto. Galeae erectae usque ad ± 12 mm., deinde arcuatae, apicibus acutis. Petala lateralia in inferioribus dimidiis linearo-oblonga, in superioribus falcata, acuta. Sepala lateralia linearia, usque ad ± 8 mm. connata, deinde in lobos 2, ± 1·2 cm. longos, erectos, acuminatos producta.

* The Waimakariri station mentioned by Kirk (*Student's Flora*, p. 71, 1899) appears to be based on a mistake. There are no specimens thence in his herbarium. The original specimen from Dunedin was (according to information supplied by the Hon. G. M. Thomson, taken from his original notes of many years ago) gathered from a plant cultivated in a garden.

Labellum subcrassum, latericium, linearo-oblongum, marginibus minute serrulatis; in canaliculatum, minute retusum, paulo exsertum apicem angustatum. Unguis curvatus, apice 2 longis et aliquis brevibus satis latis filamentis ornatus. Columna gracilis, galeam partem erectam aequans; auriculae decurrentes, superioribus lobis late triangularis, apice breviter acuminatis; inferioribus lobis late oblongis, obtusis, apice mollibus pilis vestitis.

North Island: Wellington Botanical District—On margins of subalpine scrub, and in lower subalpine herb-field, about 1,200 m. altitude, Ruahine Mountains, near Apiti: H. H. A.

Though coming into the group containing *P. Banksii*, *P. australis*, *P. graminea*, that have cauline leaves only, this species is very distinct. So crowded are the broadly elliptic-ovate, obtuse leaves that superficially the species more closely resembles the *P. foliata* group. The plant grows in small colonies, and when growing through moss cushions the stems may be much elongated.

65. **Ranunculus maculatus** Ckn. et Allan sp. nov.

Herba parva, caespitulosa. Folia numerosa, radicalia, maiusculis brunneis maculis notata; laminae $\pm$ 9 mm. longae, $\pm$ 10 mm. latae rotundato-cuneatae, supra paulo pilosae, nervis tribus distinctis; 3-lobatae usque ad media, mediis lobis parvioribus; lobi lati, obtusi, inaequaliter 2–3 crenato-dentati; petioli $\pm$ 16 mm. longi sine vaginis, $\pm$ 1 mm. diam., erecto-patentes, pilis longis sparsis appressis induti; vaginae $\pm$ 14 mm. longae, $\pm$ 3 mm. latae, marginibus paene hyalinis. Scapi $\pm$ 5 cm. longi, satis crassi, $\pm$ 2·5 mm. diam., longis pilis induti. Sepala 5, fugacea, 3 mm. longa, 2 mm. lata, late ovata, obtusa, infra sparsis pilis obtecta, marginibus scariosis. Petala plerumque 5, ovata vel obovato-spathulata, 5 mm. longa, 2 mm. lata, flava, supra nitentia, basim versus alba. Nectarium breve, subulatum. Stamina non multa, filamentis $\pm$ 1·5 mm. longis; antherae ellipticae, 0·5 mm. longae. Carpella $\pm$ 20, glabra, aliquanto turgida. Stylus brevis, stigmate paulum recurvato.

South Island: South Otago Botanical District—In wet ground at 1,200 mm. on Rock and Pillar Range: L. C.

This seems to be a distinct species with no near relative.

66. **Ranunculus rivularis** Banks et Sol. ex Forst. f. var. **glareosus** Ckn. et Allan var. nov.

Ab varietatibus aliis speciei habitu robustiore, foliis 3-lobatis, lobulis inaequaliter 2–3 lobulatis, petalis obovato-oblongis haud linearo-oblongis, distinguitur.

South Island: Eastern Botanical District—(1) Ninety-mile Beach, L. C.; (2) mouth of Ashburton River, H. H. A. On shingly or sandy foreshore.

This variety is very closely allied to the other varieties of the species, but is apparently confined to coastal gravel or sand, a station very different from those usual for *R. rivularis*. It is of robust habit, with far-spreading rhizomes emitting tufts of dark-green leaves on long petioles, the blades being 3-lobed almost to the base, with the lobes again irregularly lobulate. In cultivation the plant becomes rampant, and in one case grew over and suppressed a common damp-ground form of the species.

Ferns and Flowering-plants of Mayor Island, N.Z.

By H. H. Allan and K. W. Dalrymple.

[*Read before the Philosophical Institute of Canterbury, 1st October, 1924; received by Editor, 24th October, 1924; issued separately, 6th March, 1926.*]

Plate 5.

Mayor Island (Tahua of the Maori) lies in the Bay of Plenty, north-north-east of Tauranga, about 32 km. (20 miles) from the mainland and beyond the 180 m. (100 fath.) depth line. The island, of volcanic origin, is somewhat square, of 1,277 ha. (3,154 ac.) extent, with a high ridge running east and west across the south end, and north and south on the western side, rising to about 396 m. (1,300 ft.) at the north end. The centre of the island is occupied by a great crater, some 8 km. (5 miles) in circumference, in which are two lakes—one of 2·5 ha. (6 ac.), dark blood-red from a distance; the other 8 ha. (20 ac.), of a deep blue-black. The colour is apparently due to the abundance of algal growth. There is a small opening, Opo Bay, on the south-east corner, the usual landing-place. Seaward there are rough water-worn cliffs streaked with veins of obsidian and surmounted by ash-beds sloping into the crater.

Dr. L. Cockayne, F.R.S., has kindly forwarded us the notes taken by him on a very brief visit to the island in February, 1905, and the following account of the vegetation is based on these and upon the notes and specimens taken by one of us (K. W. D.) during a fortnight's stay in March, 1924. We have to thank Dr. Cockayne for critically examining certain of the specimens collected.

The list of species shows that Mayor Island belongs to the Thames Subdistrict of the South Auckland Botanical District of Cockayne.*

The dominant tree is the pohutukawa (*Metrosideros tomentosa*), many specimens of which are of great size, the largest noted measuring 9 m. in circumference, with a trunk clear of branches for 3 m., and surmounted by a magnificent spreading head. The pohutukawa forms great groves in the lower flats all over the island.

The slopes of the main ridges are a continuous succession of small, deep, dry gullies, the spurs of which are clothed in thickets of manuka (both *Leptospermum scoparium* and *L. ericoides*), amongst which *Knightia excelsa*, about 3·5 m. tall, is dotted about. The gully-bottoms have a dense growth of whau (*Entelea arborescens*), and the side-slopes contain large makomako (*Aristotelia serrata*) up to *c.* 0·7 m. in diameter, *Litsaea calicaris*, *Dysoxylum spectabile*, *Suttonia australis*, *Brachyglottis repanda*, *Melicytus ramiflorus*, and odd tree-ferns. The liane *Rhipogonum scandens* is frequent, and the undergrowth is mainly *Coriaria sarmentosa*, *Rhabdothamnus Solandri*, and a few ferns. The undergrowth is, however, much altered and depleted owing to the presence of pigs, while the unstable surface militates against regrowth. The high ridges contain a dense scrub in which manuka, *Cyathodes acerosa* vars., *Leucopogon fasciculatus*, *Coprosma* spp., *Gaultheria oppositifolia* are prominent.

* See Cockayne, L., 1921. *Die Vegetation der Erde*, xiv: The Vegetation of New Zealand, p. 300 *et seq.* Leipzig: Wilhelm Engelmann.

There are small areas of swamp by the lakes, but otherwise the crater-basin is covered with pohutukawa and manuka. Much of the manuka shrubland is an indigenous-induced association on ground formerly cultivated by the Maori. In one place exists a clump of *Pinus Pinaster*, and this aggressive species threatens to extend its area rapidly. One old cultivation-ground is covered in *Hibiscus trionum*.

A small grassy flat at Opo Bay, containing scattered pohutukawa, has as its main constituents *Sporobolus indicus*, *Holcus lanatus*, *Dactylis glomerata*, *Poa pratensis*, *Lolium perenne*, *Trifolium repens*, and is thus an exotic-induced association.

There are a number of other exotic species established, especially on the old Maori clearings. Some of them are *Ricinus* sp., *Rosa eglanteria*, *Phytolacca octandra*, *Oenothera odorata*, *Rumex obtusifolius*, *Solanum nigrum*, *Anagallis arvensis*, *Erigeron canadense*.

LIST OF SPECIES OF PTERIDOPHYTA AND ANGIOSPERMAE.

The list includes 98 species or distinct varieties, distributed among 78 genera and 50 families. The abbreviations "fl." and "ft." indicate that the species were observed to be in flower or in fruit in March, 1924.

Lycopodiaceae: *Lycopodium volubile* Forst. f.

Psilotaceae: *Psilotum triquetrum* Swartz.

Marattiaceae: *Marattia fraxinea* Smith.

Cyatheaceae: *Cyathea dealbata* Swartz; *Cyathea medullaris* Swartz; *Cyathea Cunninghamii* Hook. f.

Polypodiaceae: *Adiantum hispidulum* Swartz; *Cheilanthes Sieberi* Kunze; *Pteris comans* Forst. f.; *Pteridium esculentum* (Forst. f.) Cockayne; *Blechnum capense* (L.) Schlecht.; *Asplenium flaccidum* Forst. f.

Typhaceae: *Typha angustifolia* L. var.

Gramineae: *Paspalum scrobiculatum* L. (ft.); *Oplismenus undulatifolius* Beauv. (ft.); *Spinifex hirsutus* Labill.; *Dichelachne crinita* (Forst. f.) Hook. f.; *Dichelachne sciurea* Hook. f.; *Agrostis Billardieri* R. Br.

Cyperaceae: *Mariscus ustulatus* (A. Rich.) C. B. Clarke (ft.); *Eleocharis sphacelata* R. Br. (ft.); *Scirpus nodosus* Rottb.; *Gahnia gahniaeformis* (Gaud.) Heller; *Uncinia* sp.

Liliaceae: *Rhipogonum scandens* Forst. (ft.); *Cordyline australis* Hook. f.; *Astelia Banksii* A. Cunn. (ft.); *Astelia* sp. (epiphytic); *Dianella intermedia* Endl.; *Phormium tenax* Forst. (ft.); *Phormium Colensoi* Hook. f.

Piperaceae: *Macropiper excelsum* (Forst. f.) Miq. var. *major* Cheesem.; *Peperomia Endlicheri* Miq. (fl.).

Proteaceae: *Knightia excelsa* R. Br.

Polygonaceae: *Muehlenbeckia complexa* (A. Cunn.) Meissn.

Chenopodiaceae: *Salicornia australis* Sol.; *Salsola Kali* L.

Aizoaceae: *Mesembryanthemum australe* Sol. (fl.).

Ranunculaceae: *Ranunculus hirtus* Banks et Sol. (ft.).

Monimaceae: *Hedycarya arborea* Forst. (ft.).

Lauraceae: *Litsaea calicaris* (Sol.) Benth. et Hook. f. (ft.).

Cruciferae: *Lepidium oleraceum* Forst. f. var.

Pittosporaceae: *Pittosporum Colensoi* Hook. f.; *Pittosporum crassifolium* A. Cunn.; *Pittosporum* sp. (probably *P. umbellatum*).

Rosaceae: *Acaena Sanguisorbae* Vahl. var. (ft.).
Oxalidaceae: *Oxalis corniculata* L. var. (fl.).
Meliaceae: *Dysoxylum spectabile* (Forst. f.) Hook. f. (ft.).
Euphorbiaceae: *Euphorbia glauca* Forst. f.
Coriariaceae: *Coriaria sarmentosa* Forst. f. (ft.).
Corynocarpaceae: *Corynocarpus laevigata* Forst.
Sapindaceae: *Dodonaea viscosa* Jacq.
Rhamnaceae: *Pomaderris phylicaefolia* Lodd.
Elaeocarpaceae: *Aristotelia serrata* (Forst.) W. R. B. Oliver.
Tiliaceae: *Entelea arborescens* R. Br. (ft.).
Malvaceae: *Hibiscus trionum* L. (fl. and ft.).
Violaceae: *Melicytus ramiflorus* Forst.; *Hymenanthera novae-zelandiae* (A. Cunn.) Hemsl. (ft.).
Thymelaeaceae: *Pimelea virgata* Vahl.; *Pimelea prostrata* (Forst. f.) Willd. var. (fl.); *Pimelea* sp. (= *P. Urvilleana* Cheesem. non A. Rich.).
Myrtaceae: *Leptospermum scoparium* Forst. (ft.); *Leptospermum scoparium* Forst. var. (ft.); *Leptospermum ericoides* A. Rich. (ft.) [there also occurs a form with narrow-linear leaves and small fruits that is possibly *L. ericoides* × *lineatum*]; *Metrosideros tomentosa* A. Rich. (ft.).
Onagraceae: *Epilobium cinereum* A. Rich.
Halorrhagidaceae: *Halorrhagis erecta* (Murr.) Schindl. (fl.); *Halorrhagis procumbens* (Sol.) Cheesem.
Umbelliferae: *Apium prostratum* (DC.) Labill. (fl.).
Araliaceae: *Nothopanax Sinclairii* (Hook. f.) Seem.; *Nothopanax arboreum* (Forst. f.) Seem. (ft.); *Nothopanax* sp.? [the specimens gathered include a single remarkable leaf of what may prove to be an undescribed species—there are seven sessile leaflets, the larger ones broadly obovate with tapering cuneate bases and rather distant blunt teeth: see Plate 5]; *Pseudopanax Lessonii* (A. Rich.) C. Koch.
Ericaceae: *Gaultheria antipoda* Forst. f. var.; *Gaultheria oppositifolia* Hook. f. (ft.).
Epacridaceae: *Cyathodes acerosa* R. Br. [there are distinct forms present, one of which is probably var. *oxycedrus* (R. Br.)]; *Leucopogon fasciculatus* (Forst. f.) A. Rich. (ft.); *Leucopogon Fraseri* A. Cunn.; *Dracophyllum Sinclairii* Cheesem.
Myrsinaceae: *Suttonia australis* A. Rich. (ft.).
Loganiaceae: *Geniostoma ligustrifolium* A. Cunn. (ft.).
Convolvulaceae: *Calystegia Soldanella* (L.) R. Br. (fl. and ft.); *Dichondra repens* Forst.
Verbenaceae: *Vitex lucens* T. Kirk (ft.).
Solanaceae: *Solanum aviculare* Forst. f. (fl. and ft.).
Scrophulariaceae: *Hebe salicifolia* (Forst. f.) Pennell var. (fl.).
Gesneriaceae: *Rhabdothamnus Solandri* A. Cunn. (fl.).
Myoporaceae: *Myoporum laetum* Forst. f. (ft.).
Rubiaceae: *Coprosma grandifolia* Hook. f. (ft.); *Coprosma lucida* Forst. f. (ft.); *Coprosma lucida* Forst. f. var. (ft.); *Coprosma robusta* Raoul (ft.); *Coprosma robusta* Raoul var. *angustata* Kirk? [this is a very narrow-leaved form, and may be a hybrid; it does not belong to the × *C. Cunninghamii* group.) (ft.)]; *Coprosma retusa* Hook. f.
Campanulaceae: *Lobelia anceps* L. (ft.).
Compositae: *Brachyglottis repanda* Forst.; *Senecio Banksii* Hook. f.

A leaf of *Nothopanax* sp. Mayor Island.

Vegetation of Mount Peel, Canterbury, N.Z.

Part 1.—The Forests and Shrublands.

By H. H. ALLAN, M.A., D.Sc., F.L.S.

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A. INTRODUCTION.

(*a*.) GENERAL.

THE present paper owes its inception to a statement by Cockayne (1917, p. 62), when discussing his proposed botanical districts: "The actual boundaries of many of the districts are extremely hard to fix, and in no few cases must always be artificial, though that detailed research which must take place in due course as phytogeographic workers increase in number will eventually find out the most natural limits." Observations were made at all seasons during the period 1917–21, some thirty weeks being spent in the field, in the attempt to provide one such detailed study. I am deeply indebted to my friend and master, Dr. L. Cockayne, F.R.S., F.N.Z.Inst, &c., for his unfailing interest and encouragement in all my botanical work, and for his help and criticism during the investigation.

For some sixty-five years the grasslands of Mount Peel have been carrying sheep, and for a long period the river-flats have been grazed by cattle. The forests have been partially milled, and large portions have been felled and turned into arable or pasture land. Burning has been practised extensively on the grasslands, and fire has not altogether spared the forest. The destruction of the forest still continues, but fortunately a considerable area has been created a scenic reserve. Obviously the present facies of the vegetation must differ considerably from its primitive condition, and successions now in progress must differ greatly in most cases from those which produced the primitive vegetation. Admirably suited to the needs of students of such vegetation is the classification of associations given by Cockayne (1919, p. 147): (1) primitive, (2) modified, (3) indigenous-induced, (4) adventitious-induced, (5) artificial. I also follow Cockayne (*e.g.*, 1921, *passim*) in his usage of the terms "formation," "association," "subassociation," "colony." The term "relic" I apply to fragments of communities that persist in the midst of associations that have reached a further stage in the succession—*e.g.*, relic river-bed communities in tussock-grassland, relic beech forest in rain forest. Individual plants may also be relics of a community that has passed by—*e.g.*, *Polystichum vestitum*, a relic of forest. In some cases it is difficult to decide whether a community is relic or indigenous-induced.

(*b*.) PHYSIOGRAPHY AND CLIMATE.

The area examined is some 11,000 ha. (27,000 ac.), having its centre in about 43° 52′ S. lat. and 171° 12′ E. long., and is included in the Eastern Botanical District of the Southern Botanical Province, as delimited by Cockayne (*l.c.*, 1917, p. 65). The Rangitata River from just below its gorge forms the eastern boundary for some 12 km. (7½ miles), and the

long gorge of the Orari forms the western boundary. The southerly-facing slopes arising from the plain, here 270 m. (886 ft.) above sea-level, reach 1,308 m. (4,291 ft.) in the peak of Little Mount Peel. Thence the crest of the ridge runs north-west, descending to 1,125 m. (3,691 ft.), and rising in the rounded mass here called Middle Peel to 1,585 m. (5,200 ft.), and culminating in the double peak of Big Mount Peel at 1,740 m. (5,709 ft.). The northern boundary is formed by streams running to the Orari and Rangitata from the saddle, 1,220 m. (4,003 ft.), immediately to the north of the summit. The southern boundary is formed by the remnants of forest on the plain. Numerous streams descend to both rivers from the ridge, several of the eastern ones joining to form the Lynn. On all these streams a series of waterfalls and miniature gorges occur. Small shingle-fans end the eastern streams, while the streams of the western slopes form small hanging valleys ending in waterfalls into the Orari. Both Big and Little Mount Peel are sharp in outline, with much-shattered rocky summits and numerous rock-buttresses, whereas Middle Peel is covered with finer debris and gives rise to fairly extensive screes (shingle-slips). The spurs leading to the main divide lie athwart the prevailing north-west winds, and have a higher average elevation as one proceeds along the ridge towards Big Mount Peel. The topography is thus of a youthful character, and offers varied habitats for plant communities. The main mass of the mountain is formed of the comparatively easily-weathered greywacke rock.

The outstanding climatic features affecting the vegetation are the rainfall, snowfall, and wind. Mount Peel lies within the rain-band of 760–1,020 mm. annual fall, which stretches throughout the South Island, narrow in Canterbury and broadening out in Marlborough and Otago. Peel Forest itself, however, has a somewhat higher mean annual rainfall, as shown in the following table, recalculated in millimetres from the *Journal of the Canterbury Agricultural and Pastoral Association* for 1918, 1919, and 1920. The mean value is stated to be derived from records of "a considerable number of years."

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1917 ..	50·0	67·1	111·8	72·6	148·6	44·7	121·2	98·8	243·3	102·1	79·0	275·1	1,414·3
1918 ..	132·9	128·5	101·2	32·3	16·8	66·6	26·4	87·6	80·5	122·4	141·0	122·4	1,066·8
1919 ..	165·0	6·4	28·2	101·3	12·4	62·2	114·6	85·3	190·0	40·4	130·6	121·2	1,138·5
Mean..	116·6	110·7	126·7	95·3	63·0	77·0	83·8	57·4	94·5	97·1	106·7	118·9	1,147·2

The difference in rainfall over a period of nine years between Mount Peel Station, exposed to the dry north-west winds sweeping down from the Rangitata Gorge, and Peel Forest, sheltered in a basin of hills, is as follows: Mount Peel (mean), 960·15 mm.; Peel Forest (mean), 1,164·81 mm. Rain is fairly generally distributed over the year; any month may have a fall of over 150 mm., the average monthly rainfall being over 95 mm. In addition the number of cloudy days on the forested area is considerably in excess of that elsewhere. Speight, Cockayne, and Laing (1911) have sufficiently dealt with the influence of the Southern Alps on the rainfall and climate of the eastern ranges and plains. The influence of wind is dealt with later on.

From some 1,200 m. upwards on the Rangitata face of the mountain snow lies practically throughout the winter, though a strong north-west wind, even in midwinter, may temporarily clear the slopes in a remarkable manner. On the southern slopes the line of winter snow falls *c.* 200 m.,

and the snow remains much later in the season. From 1,200 m. down to 650 m. snow lies for weeks at a time on the southern face, and for lesser periods on the Rangitata face. Below this elevation snow may fall at any season, but usually lasts only a few hours. The great influence of snow upon the vegetation at Mount Peel will be clear from the detailed descriptions which follow, especially in regard to the formation of the belts.

Of the past climatic history of the area, most importance attaches to the post-glacial period. This has been dealt with by Speight (1911), and as to its botanical significance by Speight, Cockayne, and Laing (*l.c.*, 1911, p. 343). During the period of glaciation the higher peaks of Mount Peel probably rose above the glacier-field as nunataks, and the special features of the summit vegetation, as well as more general questions raised, are dealt with later on.

(c.) THE FORMATIONS AND THEIR PHYSIOGNOMY.

The broad features of the plant-covering are due to the interaction of the major factors briefly discussed above: (1) Topography, (2) climate, (3) the glacial period, (4) the greywacke substratum. Great modifications have been caused by the advent of man, but the belts of vegetation still persist with a semi-primitive appearance and character. The lower slopes of Little Mount Peel from *c.* 600 m. downwards to the south-west, south, and south-east are clad in rain forest, which extends on to the upper plains, where it is now broken into fragments. Above the forest is an extensive belt of tall-tussock grassland, merging, on the Orari and Rangitata faces, below into low-tussock grassland, above into fell-field or herb-field, and finally into the open formation of the summit peaks. On the southern face the tall-tussock grassland merges below into a belt of *Phormium Colensoi* with *Blechnum capense*, in which *Aciphylla Colensoi* is prominent, thence by way of an interrupted belt of shrubland into the forest. Scattered through the tall-tussock grassland on the southern and western aspects occur more or less extensive patches of scrub, which, with the brown of *Dracophyllum* or the green of *Hebe*, diversify the tawny grassland. Lining the narrow stream-valleys are fringing forests, dark green below, and sage-green above owing to the groves of *Gaya ribifolia*, To the north especially towards the Orari, the slopes contain occasional dark masses of subalpine beech forest, merging above into scrub and then the shingle-slips. Below the terrace of the Rangitata lies its broad river-bed clothed in great stretches of gorse.

B. THE FORESTS.

(a.) GENERAL.

Both the main types of New Zealand forest occur at Mount Peel—the rain forest and southern-beech forest. The southern-beech forest belongs to the subalpine beech-forest association, with *Nothofagus cliffortioides* as its sole dominant and only tall tree. It is the climax forest of the eastern mountain-ranges of Canterbury. The rain forest groups naturally into two associations—that of the terrace lands, dominated by *Podocarpus dacrydioides*, *P. spicatus*, and *P. totara* in varying proportions according to the edaphic conditions, and that of the hill-slopes, characterized by the infrequence of the podocarps, by the lack of any dominance in general, and by the development of several distinct subassociations. This rain forest is in marked contrast with the southern-beech forest at similar

altitudes on Mount Somers (mean rainfall 857 mm.) and Mount Hutt (mean rainfall 1,048 mm.), and may be correlated with the more favourable conditions of sheltered situation and rather greater rainfall.

The composition of the rain forest as a whole is as follows: Pterid phyta —8 families, 19 genera, 43 species; Gymnospermae—2 families, 2 genera, 4 species; monocotyledons—6 families, 12 genera, 19 species; dicotyledons—31 families, 53 genera, 89 species. The Polypodiaceae have 24 species, Hymenophyllaceae 8, Rubiaceae 9, Compositae 10. Represented by 1 species each are 17 families. Of the 155 species, 23 may be classed as abundant, 71 as more or less common, 45 as occasional to infrequent, 16 as rather rare.

The growth-forms include 6 small tuberous-rooted herbs (5 summer-green, 1 saprophytic); 3 simple rosette herbs; 41 tuft plants (including 18 tuft-ferns, 6 tree-ferns, 9 grass-like herbs); 2 trailing herbs; 16 lianes; 26 creeping plants (8 patch-herbs, 3 mat-plants, 15 sheet-plants); 61 bushy plants (including 3 herbs; 1 semi-woody plant; 30 trees—3 tall, 8 medium, 19 small; 27 shrubs—14 open-branching, 4 fastigiate, 9 divaricating). There are thus 80 herbaceous species, 3 semi-woody, 72 woody. There are 15 ferns that occur as epiphytes, and 3 hemi-parasitic shrubs.

(*b*.) The Podocarp Forest.

1. *Composition.*

The podocarp forest may best be described in two sections, though these merge into one another. On the flood-plain of the Rangitata at about 240 m. *Podocarpus dacrydioides* is dominant, with *P. spicatus* subdominant. Seen from above, this section presents a billowy appearance, *P. dacrydioides* reaching 27 m. and overtopping *P. spicatus* by some 4–5 m. *P. totara* is infrequent. Near the base of the terrace-slopes, where streams from the mountain and ooze from the terrace cause a development of swampy ground, we get true but limited *P. dacrydioides* swamp forest. *Wintera colorata* is abundant, often attaining 9 m. Below there is a dense undergrowth, which may be mainly juvenile *P. dacrydioides*, or contain varying amounts of *Wintera colorata, Coprosma rotundifolia, Melicytus micranthus, Myrtus pedunculata, Griselinia littoralis*. These are largely covered with lichens, liverworts, and mosses. On the floor and scrambling over the shrubs are occasional *Rubus schmidelioides*. The floor-plants are *Uncinia uncinata, Nertera dichondraefolia, Blechnum discolor, Microlaena avenacea, Hymenophyllum demissum*, but only where there is not an excess of water. Climbing up the trees is much *Cyclophorus serpens*. Near streams other shrubs occur, notably *Carpodetus serratus, Schefflera digitata, Fuchsia excorticata, Nothopanax arboreum, Hebe salicifolia* var. *communis*. Ferns are more numerous, and include *Blechnum fluviatile, B. lanceolatum, Asplenium bulbiferum, Polypodium diversifolium*. Here, too, occur *Pterostylis Banksii, Stellaria parviflora, Pratia angulata*, and other herbs. Where the floor becomes drier the ground-plants are mainly *Astelia nervosa, Polystichum vestitum, Asplenium bulbiferum. Suttonia australis* becomes a common undergrowth shrub, and here *P. spicatus* is subdominant, while *Elaeocarpus Hookerianus, Nothopanax arboreum*, and *Pennantia corymbosa* become common; *Asplenium flaccidum, Polypodium grammitidis, Cyclophorus serpens* occurring on them. There will be odd *Dicksonia fibrosa*. On the steep terrace-slopes *P. totara* enters in, and the association merges into the next section characteristic of the upper terrace-flats. In general *P. spicatus* is dominant, with *P. totara*, and *P. dacrydioides* in lesser

amounts. Here and there, but little inferior in height to the podocarps, is *Elaeocarpus Hookerianus*. The second layer is composed of *Griselinia littoralis*, *Nothopanax arboreum*, *Schefflera digitata*, *Carpodetus serratus*, *Pittosporum tenuifolium*, with the usual fern epiphytes. The shrub layer is mainly made up of *Wintera colorata*, *Coprosma rotundifolia*, *C. rhamnoides*, *Fuchsia excorticata*, *Aristotelia serrata*. *Metrosideros hypericifolia* creeps over the ground and climbs high among the trees. The chief floor-plants are *Polystichum vestitum*, *Uncinia uncinata*, *U. riparia*, *Blechnum discolor*, *Polypodium diversifolium*. There are numerous seedlings, especially parsonsias and podocarps. On the outskirts is a tangle of various *Rubi*, *Calystegia tuguriorum*, *Parsonsia heterophylla*, *Clematis indivisa*, *C. foetida*, and *Metrosideros hypericifolia*, the last especially abundant.

Where the floor is low-lying and damp the association closely resembles the flood-plain section, and in gullies merges into the hillside forest. On the drier ground, even when the ground is only slightly higher, *P. dacrydioides* practically disappears, being replaced by *P. totara*. This becomes dominant on the driest areas. Here *Suttonia australis*, *Pennantia corymbosa*, *Hoheria angustifolia*, *Plagianthus betulinus*, *Edwardsia microphylla* become common in the second layer, with occasional *Melicytus lanceolatus*, and more or less *Pseudopanax crassifolium* var. *unifoliolatum*, *Coprosma linariifolia*, *Melicytus ramiflorus*. *Melicope simplex*, *Nothopanax anomalum*, and to a less extent *Fuchsia Colensoi* and *Coprosma areolata* enter the shrub layer. On banks and stony places occur *Asplenium flabellifolium*, *A. Hookerianum*, *A. flaccidum*, and occasionally *Lycopodium volubile*, and sheets of *Hydrocotyle americana*, *H. moschata*, *Schizeilema Hookeri*. On the forest-margin *Senecio sciadophilus* is added to the lianes.

2. Plagianthus betulinus *Subassociation.*

Plagianthus betulinus is known to form indigenous-induced associations, but the community at Mount Peel appears to be a remnant of a primitive subassociation, as the trees are adult, up to 15 m. tall, and reach 0·6 m. diameter at 1 m. from the base. The community now occurs only in certain fragments, and is much modified owing to the isolation of the fragments and the intrusion of stock. Besides the dominant tree, there are less amounts of large *Griselinia littoralis* and *Hoheria angustifolia*, with occasional adult *Pseudopanax crassifolium* var. *unifoliolatum* and *Fuchsia excorticata*. The undergrowth is made up of *Coprosma linariifolia*, *Melicope simplex*, *Pseudopanax crassifolium* (juvenile), with the usual lianes. The shrubs are sparse, and the floor is clothed mainly with exotic species, of which *Poa pratensis*, *Holcus lanatus*, and *Dactylis glomerata* are the chief. Where the undergrowth is dense the grass covering is replaced by *Polystichum vestitum* and odd seedlings, mainly parsonsias, *Suttonia australis*, *Griselinia littoralis*, *Pittosporum tenuifolium*.

3. *Successions.*

(1.) *Milled Forest.*—Forest that has been milled has two characteristic features: (i) The entry of various aliens, especially those of the "berried" type—*e.g.*, *Hypericum Androsaemum* and *Rubus fruticosus*; (ii) the rapid growth of certain of the smaller trees and shrubs. *Aristotelia serrata* often forms thickets of slender stems 5–6 m. tall, *Fuchsia excorticata* also increases greatly, while *Wintera colorata* and *Carpodetus serratus* grow into small trees. Lianes often increase greatly and convert the forest into an almost impenetrable mass. *Hoheria angustifolia* does not increase markedly in such forest. Where cattle enter milled forest

open spaces increase and the forest becomes separated into clumps. Of especial attraction to cattle are *Uncinia* spp., *Carex* spp., and to a less extent *Microlaena avenacea*. Certain shrubs—*e.g.*, *Schefflera digitata*, *Nothopanax arboreum*—are also fed on. Where cattle do not penetrate, seedling podocarps and other species of the original forest become established, and the forest progresses towards its previous condition.

(2.) *Succession to* Podocarpus dacrydioides. — The succession from swamp to *Podocarpus dacrydioides* may be traced in places adjacent to the adult podocarp association. *P. dacrydioides* and *Griselinia littoralis* establish themselves in the swamp, which has *Olearia avicenniaefolia*, *Coprosma* spp. on its margin, and in some cases *Olearia virgata* var. and *O. lineata* are members of the swamp community. *P. dacrydioides* becomes dominant and forms thickets. The following description of the progress of such thickets is taken direct from my notes: The *P. dacrydioides* are here some 30–50 cm. apart, have a basal diameter of $\pm$ 12 cm., and a height of 9–14 m. The tall slender trunks are sparsely clad with short branches, and end in a small canopied head of foliage. The shrubs are few and poorly developed, and include *Suttonia divaricata*, *Coprosma rotundifolia*, *Wintera colorata*, *C. parviflora*, *Pseudopanax crassifolium* var. *unifoliolatum* (juvenile), with rather larger *Griselinia littoralis*. These occur only on the patches of rather drier ground. Beneath is much *Carex secta* (*Blechnum capense* on it), *Astelia nervosa*, and, where the shrubs occur, some *Polystichum vestitum*. On the outskirts *Rubus australis* climbs to the top of the trees. Between the herbs of the floor are pools of water, slow-flowing streams, or boggy ground.

(3.) *Succession to* Hoheria angustifolia.—There are occurring on the felled areas two distinct successions—to *Poa caespitosa* grassland, and to *Hoheria angustifolia* thickets. The former is in a very early stage, the tussock grassland forming at present only clumps of varying size scattered here and there on the artificial grassland. The second is a characteristic feature of the grassland. The scattered clumps of *Hoheria angustifolia* are found in all stages from an open community of juvenile plants of the usual divaricating form to groves of adult trees in closed association. By the time the hoherias are assuming adult form above the community becomes so dense as to form thickets, in which seedlings of the following species become more or less common: podocarps, *Edwardsia microphylla*, *Pennantia corymbosa*, *Elaeocarpus Hookerianus*, *Fuchsia excorticata*, with various coprosmas. As these develop, the groves assume the form of young mixed forest. This stage is especially well developed as a defined margin to the existing forests in certain places. *Polystichum vestitum*, a relic from the original forest, increases greatly in amount, and other ferns and the lianes become plentiful. On the low-lying damper areas *Podocarpus dacrydioides* enters with the *Hoheria*, and early on becomes physiognomically important. On the drier stony ground sheep penetrate the clumps as the divaricating stage passes away, use them as camping-places, destroy the undergrowth, and induce a grassy ground-vegetation.

(c.) The Forest of the Mountain-slopes.

1. *Composition.*

The mixed podocarp forest gradually merges into the forest that clothes the slopes and fills the gullies of Little Mount Peel up to about 600 m. As one ascends, *Podocarpus dacrydioides* disappears almost at once, soon followed by *P. spicatus*; but occasional examples of *P. totara* occur throughout—large by stream-sides, dwarfed on slopes and ridges. The general

groundwork is made up of the following species in greater or less abundance: *Griselinia littoralis, Nothopanax arboreum, Pittosporum tenuifolium, P. eugenioides, Edwardsia microphylla, Aristotelia serrata, Hoheria angustifolia, Melicytus ramiflorus, Leptospermum ericoides, Metrosideros lucida, Fuchsia excorticata, Pseudopanax crassifolium* var. *unifoliolatum, Suttonia australis, Olearia avicenniaefolia.* The most common shrubs of the undergrowth are *Wintera colorata, Nothopanax simplex, Suttonia australis, Suttonia divaricata, Coprosma rotundifolia, C. rhamnoides, C. linariifolia.* All the lianes occur except *Senecio sciadophilus, Rubus australis* being usually in great abundance. The chief floor-plants are *Polystichum vestitum, Blechnum discolor, B. capense, Asplenium bulbiferum, Polypodium diversifolium, Uncinia uncinata, U. riparia, Astelia nervosa.* Seedlings of the common trees are usually numerous.

By stream-sides there is a greater variety and abundance of ferns, and *Schefflera digitata, Aristotelia serrata, Fuchsia excorticata* become prominent, the latter often being so plentiful as to be of distinct physiognomic importance, especially in its leafless winter condition. *Hebe salicifolia* var. *communis* and *Gaya ribifolia* are almost confined to the stream-side, and, as one ascends, *Olearia arborescens, Nothopanax Colensoi, Senecio elaeagnifolius* (as an open spreading small tree) become noteworthy. *Pittosporum eugenioides* is rare in or absent from the stream-side vegetation. Along the actual stream *Hymenophyllum* spp. are specially abundant, and here occur *Epilobium rotundifolium, E. linnaeoides, Erechtites glabrescens, Myosotis Forsteri, Australina pusilla, Pratia angulata, Corysanthes macrantha.* Steep banks are clad in sheets of *Blechnum Patersoni, B. capense, Hymenophyllum demissum, H. multifidum,* and *H. peltatum.* In places occur numerous *Hemitelia Smithii,* and logs, trunks of trees, and shrubs are clothed in epiphytes, mainly *Hymenophylla* and various ferns, liverworts, and mosses. Locally *Alsophila Colensoi* is prominent among great sheets of *Blechnum capense.*

The streams of the Lynn Valley are characterized by abundance of *Helichrysum glomeratum, Hebe leiophylla, Veronica Lyallii,* and the presence of *Notospartium torulosum, Veronica linifolia, Olearia fragrantissima,* and in places much *Senecio bellidioides.* Stream-side rocks and rocky walls have *Hymenophyllum pulcherrimum* and *Lycopodium Billardieri* in addition to the ferns already mentioned. Where small rocky outcrops occur on the forest-floor *Polypodium diversifolium, Cyclophorus serpens,* and *Rubus australis* are common, and, if the crevices contain much soil, *Asplenium Hookerianum, A. flabellifolium, A. Richardi.*

Vertical rock-surfaces exposed to sun and wind have scattered *Olearia avicenniaefolia, Helichrysum Selago, Hebe amplexicaulis, Danthonia setifolia, Coprosma brunnea, Notospartium torulosum, Dichelachne crinita, Agropyron scabrum* var., not always all together. Some shaded rock-surfaces are clad in *Angelica montana, Lycopodium Billardieri, Veronica Lyallii,* and green tussocks of *Schoenus pauciflorus,* or breadths of *Corysanthes macrantha* among moss, where water drips.

Spurs and ridges are either occupied by the subassociations later described, or have as the most numerous plants *Leptospermum ericoides, Suttonia australis, Metrosideros lucida, Nothopanax arboreum, Coprosma linariifolia,* a large-leaved form of *Myrtus pedunculata* and *Edwardsia microphylla.* The undergrowth is mainly *Suttonia australis, Coprosma rhamnoides,* and in the upper portions *Nothopanax simplex.* The floor is rather sparsely clothed, mainly with *Blechnum capense* (stunted), *Astelia nervosa, Uncinia uncinata, U. riparia, U. caespitosa, U. filiformis, Lycopodium volubile.* At the upper limits the association is invaded by members of the

fringing scrub—*e.g.*, *Dracophyllum longifolium* (reaching a stature of 1·5 m., with spreading branches clothed at the tips with rosettes of leaves of juvenile form, in which condition it flowers freely), *Astelia Cockaynei*, *Phormium Colensoi*, *Leptospermum scoparium*, *Cassinia Vauvilliersii*, *C. fulvida* var. *montana*, *Gaultheria rupestris*, and various small herbs, notably *Celmisia spectabilis*, *Senecio bellidioides*.

Where the ridges broaden out as they descend on to the terrace lands, plants of the stream-side creep upwards, and the undergrowth is mainly *Coprosma rotundifolia*, *Wintera colorata*, and *Fuchsia excorticata*. Here occurs the chief development of the tree-ferns *Cyathea dealbata*, *C. Cunninghamii*, and *Dicksonia squarrosa*, with a wealth of *Asplenium bulbiferum*, *Leptopteris hymenophylloides*, and *Blechnum discolor*.

2. *Subassociations.*

(1.) Leptospermum ericoides *Subassociation.*—On many of the spurs on the southern slopes is developed a distinct subassociation with *Leptospermum ericoides* dominant and often the sole tree. Seen in the flowering season, these spurs stand out against the dark background of the general mass like the veining of a vast leaf. The *Leptospermum* averages 15 m. in height, and has a long trunk crowned by a small semifastigiate head, forming with its neighbours a dense canopy. While most of the shrubs may be present, *Suttonia australis* is usually very abundant, along with *Coprosma rhamnoides* and *C. parviflora*. In places *Cyathodes acerosa*, elsewhere rather rare at Mount Peel, predominates, with it being usually *Gaultheria antipoda* vars. At its upper limits the association has an undergrowth mainly of *Nothopanax simplex*, with stunted *Griselinia littoralis* and *Olearia arborescens* prominent. The floor-plants are the same as those for the ridges in general, but also include *Blechnum penna marina*, *Cotula squalida*, and *Lagenophora petiolata*.

In some places the association appears to be decadent, with many fallen trunks and dead or dying trees. In such places *Blechnum discolor* is plentiful, and juvenile *Metrosideros lucida* occurs in varying numbers. The association descends towards the streams of the western faces of the ridges, but on the eastern faces is rapidly succeeded by the general mixed forest.

(2.) Metrosideros lucida *Subassociation.*—This occupies considerable areas on rocky knolls and on slopes with a western aspect, and may be recognized from afar by its uniform sombre colouring, or in a good flowering season by its masses of red blossom. On the knolls the *Metrosideros* is youthful, and there is evidence that it is successional to the *Leptospermum* subassociation. The *Metrosideros* is the sole tree, *c.* 7 m. high, of a semi-fastigiate habit, much branched from the base, with slender naked branches each carrying a small canopied head of foliage, the whole forming a dense cover. The undergrowth is similar to that of the *Leptospermum* association, and is usually sparse. At the lower elevations *Coprosma linariifolia* is occasional, as tall as the *Metrosideros*, with trunks *c.* 13 cm. diameter. At the higher elevations occurs rarely small *Libocedrus Bidwillii*. On the slopes the *Metrosideros* is often adult, and the floor has a close cover of well-grown *Blechnum capense* with frequent *Alsophila Colensoi*, or near streams the *Blechnum* may be replaced by sheets of luxuriant *Gleichenia Cunninghamii*, forming almost pure colonies.

(3.) Nothofagus cliffortioides *Association Relic.*—At an elevation of some 510 m.—*i.e.*, near the upper forest-margin—and at stream-junctions at a lower elevation, in a few places, occur small patches of *Nothofagus cliffortioides* forest quite distinctly marked off from the surrounding forest-mass. The

communities appear to be relics from a more widespread association that has been replaced by the rain forest. The association as developed on the knolls contains *Nothofagus cliffortioides* as the sole tree. The trees, averaging 12–15 m. high, with trunks up to 50 cm. diameter, form a dense canopy, under which the undergrowth is scanty, consisting of odd stunted *Suttonia australis, Metrosideros lucida, Nothopanax simplex, Coprosma microcarpa, Melicope simplex, Gaultheria antipoda, Leptospermum ericoides, Cyathodes acerosa,* scattered widely. At the junction with the rain forest many of the rain-forest shrubs occur. The floor-plants are also sparse and stunted, and include *Astelia nervosa, Pteridium esculentum, Blechnum capense, Polypodium diversifolium, Celmisia spectabilis. Elytranthe flavida* is occasional. Seedling beeches are absent. Other examples of the community are reduced to a few old decadent trees amidst the incoming rain-forest species.

In the examples occurring at stream-junctions the floor is often covered in *Dicranoloma* moss-cushions, the trees are more youthful, with odd old decadent trees, and a litter of old trunks and broken limbs. Seedling beeches are very infrequent. *Coprosma rhamnoides, C. parviflora, C. microcarpa, Aristotelia fruticosa, Suttonia australis, Cyathodes acerosa, Helichrysum glomeratum* are the commonest shrubs. *Elytranthe flavida* is fairly common, and *Botrychium australe* is common in several forms. Other occasional floor-plants are *Polystichum vestitum, Uncinia uncinata, U. riparia, Blechnum capense, B. penna marina, Polypodium diversifolium.*

(4.) Melicytus ramiflorus *Subassociation.*—At the Lynn Valley *Melicytus ramiflorus* forms subassociations, especially on westerly-facing slopes. The *Melicytus* becomes a good-sized tree (some specimens reaching a height of 11 m. with a diameter near the base of c. 50 cm.), usually much branched from near the base. Scattered among the *Melicytus* are occasional *Edwardsia microphylla, Plagianthus betulinus, Hoheria angustifolia, Griselinia littoralis, Nothopanax arboreum.* Undergrowth is very scanty indeed, there being little else but *Suttonia australis* and *Griselinia littoralis.* As one ascends the gullies the association merges into the mixed forest. The floor is stony and bare. The herbs are distant and small, mainly *Pellaea rotundifolia, Asplenium flabellifolium, A. bulbiferum, Polypodium diversifolium, Astelia nervosa.* Seedling *Melicytus* and *Edwardsia* are frequent.

(5.) Gaya ribifolia *Association.*—At the upper margins of certain gully-forests, and as isolated patches at higher elevations c. 750–900 m., occur groves of *Gaya ribifolia,* which elsewhere is an occasional member of stream-side forest. The association occurs on stony ground by stream-sides where there is a certain degree of shelter from strong winds. The *Gaya* is the sole tree (averaging 5 m. in height), and beneath is usually little but scattered *Hypolepis Millefolium, Polystichum vestitum, Blechnum penna marina,* and sometimes *Coprosma propinqua, C. parviflora, C. ramulosa, Hebe buxifolia* var. *odora.* With a less dense cover the shrubs become more numerous. The groves form a marked physiognomic feature, bare of foliage in winter, white with blossom in summer, sage-green at other periods. The association is somewhat xerophytic in character, and is not a part of the rain forest, being treated here merely for convenience.

3. *Successions.*

(1.) Aristotelia serrata *Succession.*—This indigenous-induced association is well known as a successional stage towards regeneration of forest that has been destroyed by fire, and presents no special features at Mount Peel. It occurs in several places on the lower slopes where fire has run up from

the felled bush below. The *Aristotelia* forms dense thickets of tall slender stems (5–8 m. high), and contains a good deal of *Fuchsia excorticata* of small size. As shrubs, occur *Wintera colorata*, *Melicytus ramiflorus*, *Suttonia australis*, *Coprosma rotundifolia*. *Blechnum discolor* and *Polystichum vestitum* are more or less abundant, sometimes replaced by *Blechnum capense*. *Rubus australis* and *Muehlenbeckia australis* are frequent. Old *Griselinia littoralis* is almost the sole survivor from the original vegetation. Seedlings of many of the mixed-forest plants are frequent. On the damper slopes *Fuchsia excorticata* is subdominant.

(3.) Leptospermum ericoides *Succession.*—Thickets of *Leptospermum ericoides* occur on the more sunny slopes, both after burnt forest, and after sown grassland on felled areas. In the first case the ground is rapidly clothed in dense young *Leptospermum*, in which various seedlings get a root-hold, notably *Pittosporum tenuifolium*, *Griselinia littoralis*, *Nothopanax arboreum*, *Suttonia australis*, *Carpodetus serratus*, *Pseudopanax crassifolium* var. *unifoliolatum*, *Hebe salicifolia* var. *communis*, with *Rubus australis*, *Coprosma rhamnoides*, *C. parviflora*, and various ferns. Examples are met with where these forest species are beginning to dominate the *Leptospermum*.

On the artificial grassland the succession takes a different course where *Polystichum vestitum* survives the burning, its tussocks gradually overshading the grasses and other exotic and indigenous herbs. *Fuchsia excorticata*, *F. Colensoi*, *Hoheria angustifolia* are early comers along with the *Leptospermum* (both *L. scoparium* and *L. ericoides*), and *Rubus australis* forms mounded heaps. With the dominance of *Leptospermum*, thickets resembling the first described are reached.

(4.) *Minor Successions.*—In the *Melicytus ramiflorus* subassociation not infrequently patches are broken down by winter snows. In such places *Rubus australis*, *Muehlenbeckia australis*, *M. complexa*, and *Calystegia tuguriorum* rapidly form dense tangles. Growing up through such tangles are to be noted *Hebe salicifolia* var. *communis*, *Plagianthus betulinus*, *Edwardsia microphylla*, and *Griselinia littoralis*, which gradually assume dominance.

In several of the gully-forests more or less extensive slips have started successional movements. The actual course of events varies somewhat according to the nature of the surface exposed, the aspect of the slope, and the surrounding vegetation.

On the drier sunnier slopes early comers are *Epilobium pedunculare*, *E. microphyllum*, *Gnaphalium collinum*, *Erechtites quadridentata*, and *Pteridium esculentum*. *Poa caespitosa*, *Danthonia semiannularis*, *D. pilosa*, *Dichelachne crinita*, and various exotics, especially *Verbascum Thapsus*, *Hypochaeris radicata*, *Rumex acetosella*, come in. Early shrubs to establish are *Olearia avicenniaefolia*, *Fuchsia Colensoi*, *Hebe salicifolia* var. *communis*, *Pittosporum tenuifolium*, and the exotic *Leycesteria formosa*. Lianes capable of forming mounded heaps—*Muehlenbeckia australis*, *M. complexa*, *Rubus australis*, *R. cissoides*, *R. subpauperatus*—are more or less common.

On damper slopes the sequence is more rapid, and *Coriaria sarmentosa* and *Griselinia littoralis* are prominent, as are *Acaena Sanguisorbae* var. *pusilla* and *Calystegia tuguriorum*. Trees of the neighbouring forest establish more rapidly.

(*d.*) Subalpine Southern-beech Forest.

This forest is quite isolated from the rain forest, and occurs at higher elevations on the slopes of ridges leading down to the Orari. The sole tree is *Nothofagus cliffortioides*, many of large size, with trunks up to 1 m. or more in diameter. The largest trees are decadent, with projecting dead branches and excessive amounts of *Elytranthe flavida*. Quite striking is the absence of seedling and juvenile beeches. As one ascends, the trees

become smaller, and near the crests of the spurs are quite dwarfed owing to exposure to wind. The forests are accessible to sheep, which use them as shelter, and have probably caused the undergrowth to be sparser than in the primitive condition. There are occasional *Coprosma linariifolia, C. parviflora, Aristotelia fruticosa*, and more rarely *C. microcarpa.* On the floor are odd small patches of stunted *Blechnum capense, Polystichum vestitum, Blechnum penna marina*, and in rocky places *Asplenium flabellifolium, Acaena Sanguisorbae* vars., *Celmisia spectabilis.* At higher elevations occur *Lycopodium fastigiatum* and *Hymenanthera dentata* var. *alpina.* Along streams there is a more varied vegetation, including *Hebe salicifolia* var. *communis, Aristotelia serrata, Gaya ribifolia, Griselinia littoralis, Olearia avicenniaefolia*, and in damper spots *Danthonia Cunninghamii, Oxalis lactea, Anisotome aromatica* var. *incisa, Angelica montana*, and other species, along with various ferns, among which *Asplenium Trichomanes* and *A. Richardi* are noteworthy.

(*e.*) CONSIDERATIONS DERIVED FROM THE STUDY OF THE FORESTS.

From a study of all the examples of *Nothofagus cliffortioides* forest now existing it would appear probable that *Nothofagus cliffortioides* once clothed the sheltered sides of all the gullies. The greater rainfall in the area to the south of Little Mount Peel and in the deeper gullies has allowed a more mesophytic type of mixed forest to gain the ascendancy, restricting the beech to the more exposed knolls, and even threatening them with extinction there.

Supporting this view is the fact that various stages in the decadence of the beech forest on the knolls can be observed, one knoll at an elevation of *c.* 330 m. being now reduced to merely four or five beeches, among which is the ordinary mixed forest.

Some support is also given by the fact that the forest in almost equally sheltered places at Mount Somers, with a rainfall of only 857 mm., is almost entirely *Nothofagus cliffortioides* forest, while at Mount Hutt, with 1,048 mm., the forest is intermediate in character.

Such a view as to the character of the *Nothofagus cliffortioides* forest seems strongly supported by the arguments of Speight (*l.c.*, 1911, p. 408). In this paper, Speight, in attempting to trace the climate of Canterbury since the glacial period, attaches great importance to the existence of former extensive forests in Canterbury. He says: "Apart from this coastal forest there were at the beginning of settlement considerable areas of standing bush, containing totara, black-pine, and white-pine, at Mount Peel, Geraldine, Waimate, and especially on Banks Peninsula, as well as in a few other localities in hilly places favoured by a good rainfall and a rich soil. At Mount Peel a considerable area still remains. These were in all probability remnants of a regional forest containing totara which covered extensive areas on the eastern slopes of the main range of the South Island." He adds: "It is a remarkable fact, however, that the existing patches of bush occur in just those situations in which they might be expected to occur from ecological considerations had a slight desiccation of the climate come about."

Using Speight's summary, we may make the following surmises as to the history of the forest at Mount Peel:—

The general sequence of events since the glaciation of the South Island in Pleistocene and post-Pleistocene times appears to have been the following:—

(1.) Glacial conditions, with probable steppe climate existing con temporaneously on the land to the east of the terminations of the

glaciers, a condition which probably continued for some time, as the glaciers were retreating. (The Rangitata glacier overrides the lower slopes of Mount Peel, which projects as a nunatak. With the retreat of the ice, fell-field is established, developing gradually into tussock-grassland on exposed slopes and *Nothofagus* forest on sheltered slopes.)

(2.) Moist climate over the tract to the east of the main range, during which the forests were established or were widely spread and the rivers built up their fans. (Mixed podocarp forest develops at Mount Peel as part of an extensive regional forest. *Nothofagus* driven from all but the exposed knolls and less sheltered slopes.)

(3.) Modified steppe conditions over the belt to the east of the main range. (Podocarp forest persists at Mount Peel, owing to especially favourable rainfall, while succumbing elsewhere. Relicts of *Nothofagus* forest enabled to retain their position, but with difficulty, and largely succumbing in the Peel Forest area.)

C. THE SHRUBLANDS.

(*a.*) Composition.

Shrublands of all degrees from very open communities to dense thickets and scrub occur in many parts of the area. Some bear a semi-primitive stamp, but the majority are more or less modified by fire or grazing, and many are reduced to fragments. Others, again, are indigenous-induced, and certain adventitious-induced associations are of importance. Although typical members of the shrub-communities described are frequent, there is sometimes a most bewildering admixture of various types. My treatment in this section is much condensed, as a full treatment would run to inordinate lengths. The following figures include all the members of indigenous communities, but omit many species that occur only as invaders or relics. Of the species that can be considered true shrubland members there are—Pteridophyta, 3 families, 10 genera, 14 species ; monocotyledons, 5 families, 12 genera, 14 species ; dicotyledons, 28 families, 49 genera, 105 species. There are 18 species of Rubiaceae, 18 Compositae, 7 Scrophulariaceae. There are 13 families represented by one species each. Of the 133 species, 22 are abundant, 51 more or less common, 43 occasional or infrequent, 17 rather rare. The growth-forms include 4 small tuberous-rooted herbs ; 2 simple rosette plants ; 20 tuft plants (4 ferns, 10 grass-like plants, 2 herbaceous, 3 semi-woody, 1 tuft tree) ; 5 trailing plants ; 13 lianes (2 ferns, 3 scramblers, 5 twiners, 3 tendril-climbers) ; 19 creeping plants, including 2 turf-forming, 6 mat-forming, 10 sheet-forming ; 70 bushy plants, including 6 leafless or scale-leaved shrubs, 20 spreading, 8 ball-like, 8 fastigiate, 22 divaricating, 4 depressed shrubs. There are 39 herbs, 8 semi-woody plants, 86 woody plants. Hemi-parasites number 4.

(*b.*) The Associations.

1. *River-terrace and Debris Shrubland.*

(1.) *Lowland.*—The association, taken broadly, is dominated by *Coprosma parviflora* and *Discaria toumatou*, and may be modified, a relic of river-bed shrubland, or indigenous-induced. On concave slopes in the low-tussock grassland, exposed to much wind and insolation, and subject to burning, dry debris slopes develop colonies of *Pteridium esculentum* with various *Rubi*, and often a good deal of *Paesia scaberula*. Scattered among these are often *Discaria toumaton*, *Coprosma parviflora*, *C. propinqua*, *Corokia Cotoneaster*, *Aristotelia fruticosa*. Or a dense scrub of these divaricating

shrubs may be formed, with *Rubus australis*, *R. cissoides*, *R. subpauperatus*, *Muehlenbeckia complexa*, *Parsonsia capsularis*, *Clematis marata*, some or all scrambling over the mass. Sometimes *Hymenanthera dentata* var. *alpina*, as an upright divaricating shrub, is included. Below the densest scrub there is little else but *Asplenium flabellifolium*. The shrubland of river-terraces and stream-fans may be almost identical with the above, or contain other species—*e.g.*, various divaricating coprosmas, *Carmichaelia subulata*, *Notospartium torulosum*, *Melicope simplex*, *Coriaria sarmentosa*, *Leptospermum scoparium*, *L. ericoides*, *Fuchsia excorticata*, *Myrtus obcordata*, *Hebe salicifolia* var. *communis*, *Hebe leiophylla*, × *Hebe Kirkii*, *Olearia avicenniaefolia*, *Cassinia Vauvilliersii*. Floor-plants are more numerous, and include *Hypolepis Millefolium*, *Pellaea rotundifolia*, *Helichrysum filicaule*.

(2.) *Montane.*—At an elevation of *c.* 600 m. occurs on coarse debris near streams an association with *Olearia nummularifolia* and *Coprosma propinqua* as dominants. There is also much *Coprosma rugosa*, *Cassinia fulvida* var. *montana*, stunted *Dracophyllum longifolium*, *Coprosma parviflora*, and sometimes *Aciphylla Colensoi*, *Phormium Colensoi*. The floor-plants are chiefly *Hypolepis Millefolium*, *Polystichum vestitum*.

(3.) *Subalpine.*—On debris slopes at *c.* 1,000 m. on small stabilized shingle-slips occurs a scrub dominated by *C. parviflora* and *C. propinqua*, with large open mats of *C. ramulosa* between. *Hymenanthera dentata* var. *alpina*, as a dense semi-cushion plant, and decumbent *Coprosma serrulata*, *Dracophyllum uniflorum*, *Aristotelia fruticosa*, *Hebe buxifolia* var. *odora*, *Aciphylla Colensoi*, *Discaria toumatou* are more or less common. The chief floor-plants are *Hypolepis Millefolium*, stunted *Polystichum vestitum*, *Blechnum penna marina*, *Lycopodium fastigiatum*, *Acaena Sanguisorbae* var. *pusilla*, *Trisetum antarcticum*. *Clematis australis* is occasional as a liane. *Gaya ribifolia* occurs infrequently.

2. Hebe buxifolia - Coprosma parviflora *Scrub.*

This occupies large areas on shaded slopes at *c.* 700–1,000 m., and is sometimes apparently a development from the subalpine scrub already described. It was formerly still more extensive, but has been broken up by fires. Besides the dominants, *Coprosma propinqua*, *C. cuneata*, *Dracophyllum longifolium*, *D. uniflorum*, *Hebe Traversii* ?, *Cassinia fulvida* var. *montana* are more or less frequent. *Hebe buxifolia* increases greatly near streams, and here *Aciphylla Colensoi* and *Coprosma serrulata* are common, the latter not developing the creeping form with underground stems, but merely becoming decumbent. *Notospartium torulosum* occurs in some examples of the scrub, up to 950 m. altitude. At the higher elevations *Hebe lycopodioides* is often very common. Of the smaller plants the chief are *Gaultheria depressa*, *Anisotome aromatica*, *Senecio bellidioides*, *Helichrysum bellidioides*.

3. Leptospermum *Shrubland.*

(1.) Leptospermum *Thicket after Grassland.*—At Mount Peel the *Leptospermum* shrublands are mainly indigenous-induced after burning of forest or grassland, but there are not wanting examples that appear to be of primitive stamp. They occur in all stages from open shrubland to dense thicket. Here the association developing on burnt grassland is described. Both *L. scoparium* and *L. ericoides* invade burnt areas, usually the former dominating. The raoulias, *Leucopogon Fraseri*, *Lycopodium fastigiatum*, *L. scariosum*, that also invade burnt areas, are more or less suppressed by the rapid growth of the *Leptospermum*, as are *Dracophyllum* spp. and *Gaultheria antipoda*. The sunnier slopes favour *Leptospermum*, the shadier *Dracophyllum*. The chief other plants occurring in the later stages are

Botrychium australe, small *Pteridium esculentum* and *Blechnum capense*, *Uncinia caespitosa*, *U. riparia*, *Microtis unifolia*, *Prasophyllum Colensoi*, *Lagenophora petiolata*.

(2.) Leptospermum *Swamp.*—There are one or two examples of small swampy areas on grassland after felled forest with *Leptospermum ericoides* and *L. scoparium* dominant in varying proportions. Large mats of *Nertera depressa* surround the trunks, among which the water finds its way slowly downwards. On the mats are any of *Blechnum penna marina*, *Epilobium nummularifolium*, *Forstera Bidwillii* (slender and "drawn-up"), *Luzula campestus* vars., *Thelymitra longifolia*, *Hydrocotyle asiatica*, *Uncinia riparia*, *Pratia angulata*, *Ranunculus hirtus*, *Anisotome aromatica* var. *incisa*. Some of the following shrubs are usually present: *Suttonia divaricata*, *Coprosma propinqua*, *Griselinia littoralis*, *Wintera colorata*, *Podocarpus dacrydioides* (this often abundant but small). In shallow depressions *Carex secta* may be the chief plant below, and decadent *Phormium tenax* is common, the decadence partly due to the entry of cattle, which browse on the *Phormium* and *Carex*. Where the cover is not dense occur *Scirpus inundatus*, *Ranunculus rivularis*, *Epilobium pallidiflorum*; and with the conditions approximating to bog there is little below but sphagnum, with *Blechnum penna marina* and *B. capense* prominent on it.

(3.) Leptospermum scoparium - Exocarpus Bidwillii *Association.*—Broken rocky outcrops in low-tussock grassland at its higher limits often have an association dominated by a variety of *L. scoparium* and *Exocarpus Bidwillii*. The association may be open or closed. The *Leptospermum* is here a depressed shrub with dense, stout, spreading branches clothed towards the tips with thick broad leaves. Rather less abundant are the low, dense semi-cushions of *Exocarpus Bidwillii*. Other occasional shrubs are dwarfed *Gaultheria antipoda*, *Dracophyllum longifolium*, *Hymenanthera dentata* var. *alpina*, *Hebe Allanii*, trailing *Suttonia nummularia*. Where the association is not specially dense there are, as floor-plants, *Lycopodium scariosum*, *L. fastigiatum*, stunted *Blechnum capense*, *Leucopogon Fraseri*. Standing above the mass may be *Metrosideros lucida*, as a ball-like shrub, and stunted *Podocarpus totara*.

4. Dracophyllum *Shrublands.*

(1.) Dracophyllum longifolium *Thicket.*—*Dracophyllum longifolium* is an abundant plant in various associations up to c. 900 m., where it is replaced by *D. uniflorum*. It also frequently forms closed associations on rather steep, somewhat shaded slopes, and tends to reproduce itself after destruction by fire. Floor-plants are in greater number than in the scrub associations, more light penetrating to the ground, the chief species being *Gaultheria depressa*, *Lycopodium fastigiatum*, *Anisotome aromatica*, *Senecio bellidioides*, *Leucopogon Fraseri*, *Blechnum capense*, *Poa Kirkii*, *Trisetum antarcticum*. Some of the following shrubs are usually present: *Hebe buxifolia*, *Coprosma parviflora*, *Cassinia fulvida* var. *montana*, *Gaultheria antipoda*, *G. rupestris*, *Pimelea* sp., with *Phormium Colensoi*, *Astelia Cockaynei*, *Aciphylla Colensoi*.

(2.) Dracophyllum uniflorum *Shrubland.*—On rocky buttresses and running up steep spurs, thickets or more or less open shrublands dominated by *Dracophyllum uniflorum* are a well-marked feature high up among the tall-tussock grassland. *D. Urvilleanum* also occurs, along with *Gaultheria rupestris*, *G. depressa*, *Coprosma ramulosa*, *C. parviflora*, *C. serrulata*, all in small amounts. The commonest herbs are *Celmisia spectabilis*, *Anisotome aromatica*, *Seneco bellidioides*, *Ranunculus Monroi* var. *dentatus*, *Forstera Bidwillii*, and *Microlaena Colensoi*.

(3.) Dracophyllum rosmarinifolium *Dwarf Shrubland.*—On the exposed slopes of Middle Peel an interesting dwarf shrubland occurs in more or less extensive patches amongst the fell-field and intergrading with it. The *Dracophyllum* is dominant, and associated with it are *Pentachondra pumila, Phyllachne Colensoi, Drapetes Dieffenbachii, Gaultheria depressa, Raoulia grandiflora, Celmisia laricifolia, Lycopodium fastigiatum.*

5. Cassinia *Open Shrubland.*

As noted above, *Cassinia fulvida* var. *montana* is a member, sometimes an abundant one, of various shrubland associations. In the *Blechnum capense - Phormium Colensoi* belt this *Cassinia* and *C. Vauvilliersii* frequently occur in marked amounts, forming an open shrubland. The association is indigenous-induced after burning. Burning, though only slightly affecting the *Blechnum capense,* sufficiently opens the association to allow of the free-seeding *Cassinia* to increase greatly, the seedling being tolerant of considerable shade. The remaining plants are those of the original association described later.

6. *Scrub of the Upper Margins of the Rain Forest.*

(1.) *General.*—The forest at its upper margin merges either into tall-tussock grassland by way of a narrow scrubby belt, or into one of the shrub associations above described, but there is no broad marginal belt. In the gullies the scrub consists mainly of dwarfed *Griselinia littoralis, Nothopanax Colensoi, N. arboreum, Olearia arborescens, O. avicenniaefolia, Senecio elaeagnifolius, Nothopanax simplex, Fuchsia excorticata, Hebe salicifolia* var. *communis. Rubus australis* scrambling over these completes the scrub. On the ridges the following are prominent: *Leptospermum ericoides, Suttonia australis, Senecio elaeagnifolius, Nothopanax simplex, Dracophyllum longifolium, Gaultheria antipoda.*

(2.) Senecio elaeagnifolius *Dwarf Forest.*—On certain broad ridges the mixed forest is succeeded by a rather extensive association in which *Senecio elaeagnifolius* is dominant, the remaining shrubs being quite few in numbers. The *Senecio* is here a large shrub, up to 4 m. high, much branched from the base, the branches stout, wide-spreading, naked, with loose papery bark. Above, the branches divide several times at wide angles, the branchlets ending in rosettes of closely-placed large coriaceous leaves of oval form, dark-green above, with pale-buff appressed tomentum beneath. The shrubs are close together and form a continuous canopy, beneath which the vegetation is sparse. Here and there are slender sparingly-branched *Leptospermum ericoides, Nothopanax simplex, N. Colensoi, Coprosma linariifolia, Griselinia littoralis.* Smaller still are odd bushes of *Coprosma rhamnoides* and *Gaultheria antipoda,* open in habit. The floor-plants are small in size and scattered—*Blechnum capense, Lycopodium volubile, L. Billardieri, Polypodium diversifolium.* Seen from a vantage-point above during the flowering season this association is beautiful with its masses of golden flower-heads completely hiding the foliage.

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A Die-back of *Pinus radiata* and *P. muricata* caused by the Fungus *Botryodiplodia pinea* (Desm.) Petr.

By K. M. Curtis, M.A., D.I.C., D.Sc., F.L.S., Mycologist, of the Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 14th November, 1924; received by Editor, 26th November, 1924; issued separately, 6th March, 1926.*]

Plates 6, 7.

In August of this year the attention of the writer was drawn to the presence of what seemed to be an unrecorded disease in two species of *Pinus* in the Marlborough and Nelson Districts. In Nelson the disease occurred in trees in the town itself, while in Marlborough it was reported in the country, where valuable shelter-belts of *P. radiata* were said to be seriously threatened. On a visit being paid to Marlborough to investigate the matter it was found that, while in the case of certain shelter-belts it was necessary to take prompt steps to prevent extension of the disease, this disease was not responsible for the general dying-out of pines throughout the drier parts of Marlborough; this is rather due to the combined effect of drought, a deep shingly subsoil, and the inroads of various insect pests, notably the aphis *Chermes pini* Koch. The fungus disease, however, is sufficiently disastrous in the belts in which it is established to require attention, and a description of it is therefore now given.

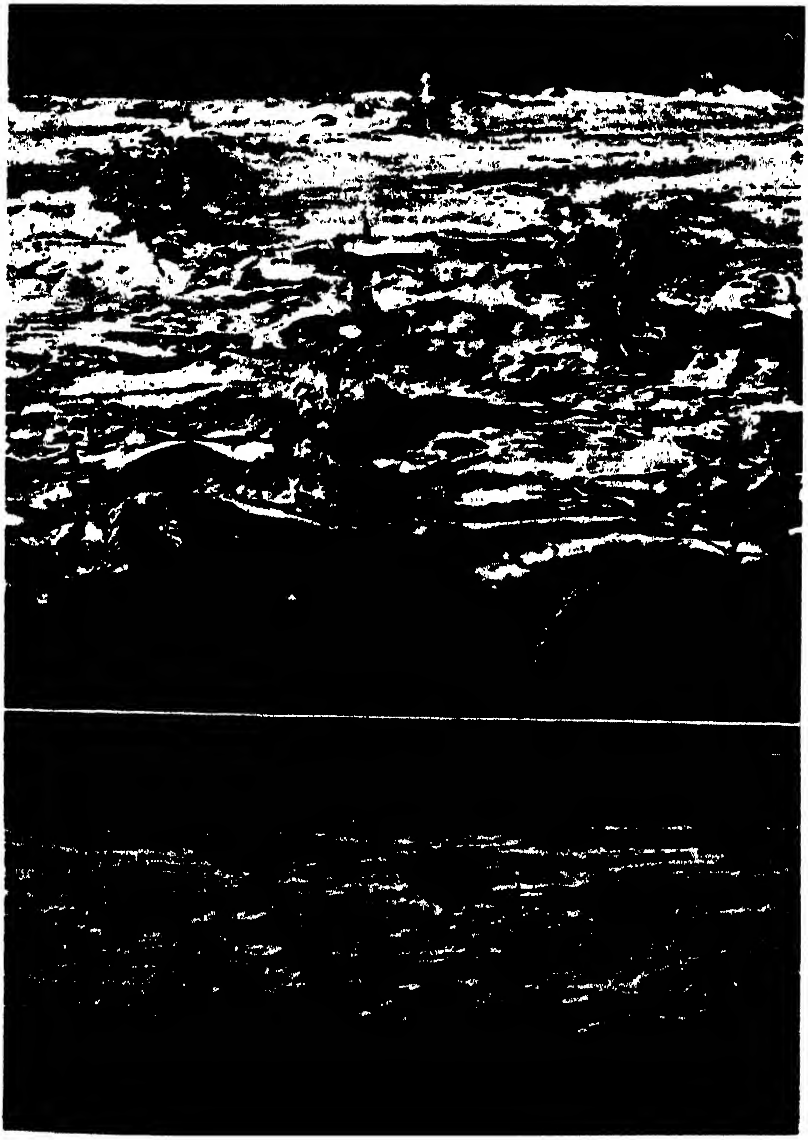
General Appearance of Infected Trees.

The disease can readily be detected from a distance, its chief characteristic being the sharp contrast presented by the diseased and the healthy parts of the tree. The tip of the stem or of one or two of the higher branches dies, the disease then extending downwards for a length of as much as 20 ft. The stem is more often affected than the upper branches, and both are more often affected than branches low on the tree, although in one exceptional instance the lowest limb of a large tree was found to be wholly invaded by the fungus.

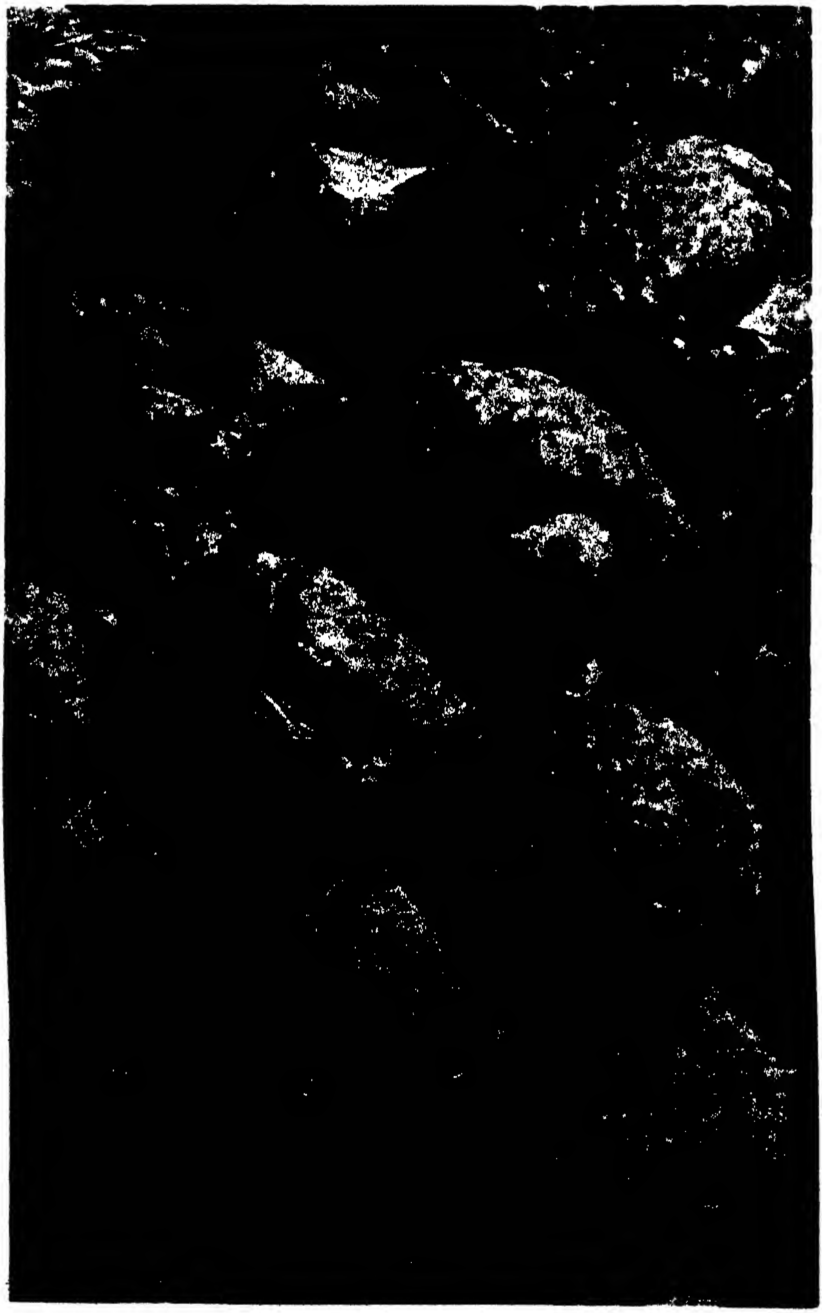
The surface of an infected area is not sunken or distorted in any way, but if sufficient time has elapsed since infection took place for reproduction of the fungus to have occurred the pycnidia formed in this process will be found studding the host-surface (Plate 6, figs. 1 and 2). The pycnidia may occur singly, but usually they are arranged in ranks or groups, the ranks being either directed straight up and down the stem or, more frequently, arranged in the shape of a narrow horseshoe, directed downwards and enclosing in the upper part of the loop the scar of a needle-bearing shoot. As a rule the ranked or curved arrangement is still indicated, even when the whole surface is densely covered with pycnidia. The continued growth of the stem eventually separates the shoot-scars and tends to straighten the sides of the horseshoe.

The pycnidia are minute and black, and as they push up the epidermis they cause it first to appear white, and then rupture it into more or less elongated slits. On the splitting of the papery-white cuticle the upper

Davies, photo



Face p. 52.]



[W. C. Davies, photo.

Cone of *Pinus radiata* bearing scattered pycnidia on the exposed surface of the scales. × 2·5.

surface of the pycnidia lies exposed. The length of the ranks of pycnidia varies from that of the diameter of a single pycnidium to 2 cm., while the width is frequently only that of one pycnidium, although it may be considerably greater.

INTERNAL APPEARANCE OF INFECTED TISSUE.

The simplest way to see the effect of the disease is to split the stem down the centre for a distance that includes several nodes. If the fungus is well established the bark and cortex are dark brown or practically black, the xylem has a cinereous tint, while the pith varies in shade from its normal rusty brown when only slightly invaded to pure black when the fungus is present in quantity. In nearly every case the tissue at the nodes where the cones are attached is more heavily infected than are the internodal regions, and it can often be seen that in a single stem infection has taken place at several successive nodes, a diseased stem- or branch-tip therefore frequently being the result of multiple infection.

The cones also become infected, but as a rule the fructifications of the fungus, instead of occurring in groups or rows, are scattered and appear singly as minute black dots piercing the epidermis (Plate 7).

THE FUNGUS.

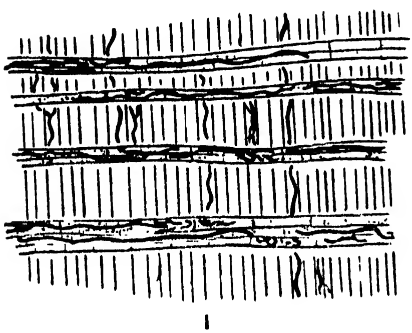
Vegetative Growth in the Host.—Whether a wound in the host-surface is necessary to enable the fungus to gain entry in the first instance is not known; but, once established, it is an active parasite. Larvae of *Sirex juvencus* L. have been found in wood infected by *Botryodiplodia pinea*, and the death of the wood has been attributed to these larvae, the fungus being regarded as merely saprophytic; but, as it is quite common to find branches suffering from fungus attack without there being any trace of the grub, this suggestion is untenable.

As already mentioned, the path of infection can usually be traced back to a node, and then out into the short stems of the cones. It would seem that in some instances cones or cone-stems when young have been the original parts infected, and that the fungus has then worked down into the stem or branch. In other cases, however, infection seems to have taken place directly in the stem or branch involved.

The hyphae, at first hyaline, soon change to a fuliginous shade, and finally become quite black, especially when near the surface of the stem. The hyphae vary in width, but the older, coloured hyphae are usually the largest, attaining an extreme width of more than 10 micromillimetres. Here and there may be seen hyphae bearing on their surface a close arrangement of small papillate outgrowths, suggestive of rudimentary haustoria. These hyphae are intercellular in position, and are usually hyaline. Growth in the cortex is vigorous, and it soon becomes a semi-stromatic mass of crushed dead cells bound together by numerous much-branched hyphae. Later, as the pycnidia are being formed, a true stroma is gradually developed beneath the epidermis, and eventually practically all the host-tissues outside the xylem become a black stromatic mass, which may extend for a considerable distance, parallel to the surface, beneath the seemingly still-intact bark.

The entry of the hyphae into the xylem takes place with few exceptions by way of the rays (text-figs. 1, 2). In radial sections of an infected area almost every cell of the rays, and particularly the median albuminous ones,

will be found to be permeated with the stout, dark strands of the fungus, and throughout the length of the ray numbers of slender branch-hyphae are given off into the tracheids, down whose length they can be traced for long distances. The hypha in a tracheid usually runs straight, but it gives off, at irregular intervals, further branch-hyphae, which as a rule pass directly through the pits in the lateral walls into neighbouring tracheids. Here they in turn commence a straight and usually downward course. Although hyphae in the tracheids are not as a rule as wide as those in the cortex, here and there one of greater width may be seen, almost filling the tracheid containing it. The colour of these larger hyphae, like those in the cortex, deepens with age to a fuliginous shade or to black, eventually causing the wood to appear cinereous to the naked eye.



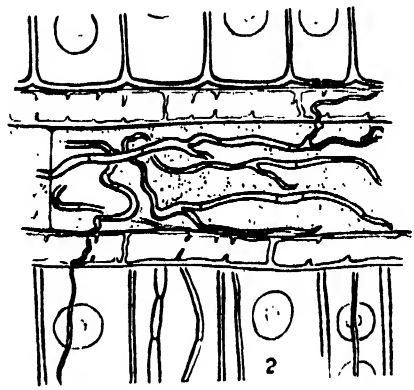
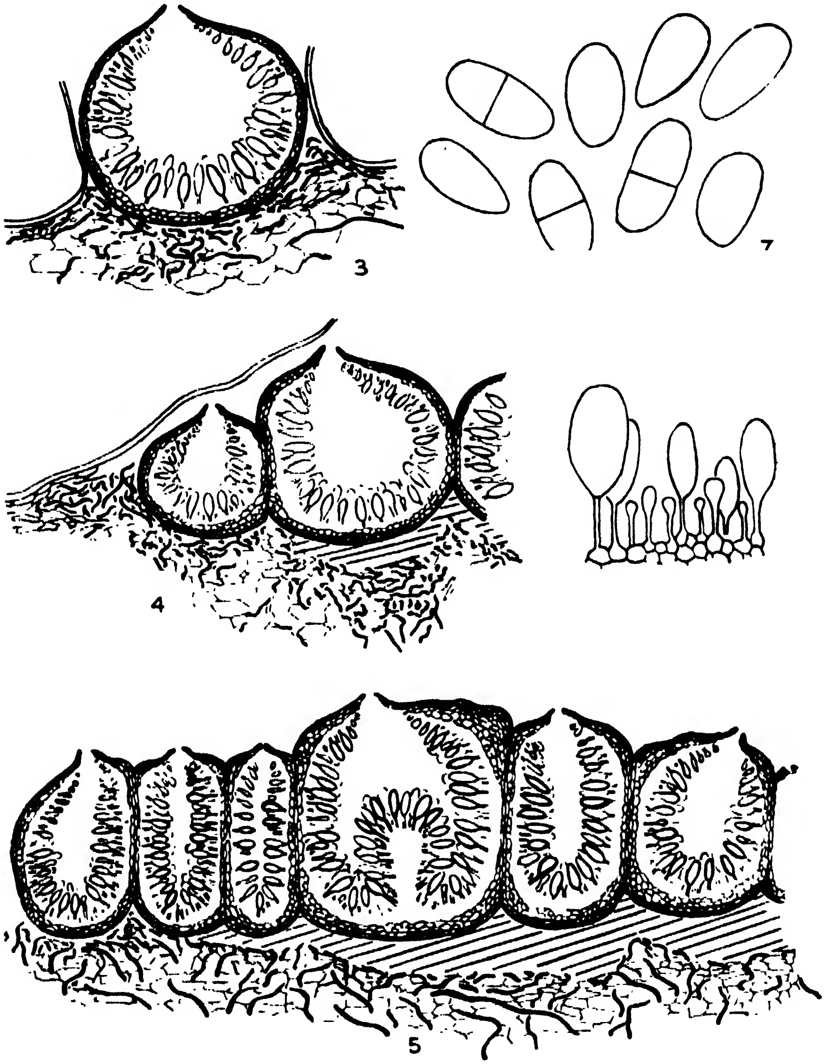


FIG. 1.—Semi-diagrammatic representation of invasion of the wood by hyphae travelling by way of the rays and thence into the tracheids.
FIG. 2.—Portion of fig. 1 enlarged. The hyphae travel chiefly through the albuminous cells of the rays. × 352.

Reproduction.—When the disease was first noticed, in August of 1924, pycnidia were already present on the surface. The spores in some of them were light brown in colour, but in most they were still hyaline. Similar stages may still be found in the original material as well as in that gathered in mid-November. The production of pycnidia thus continues for some time. The spores are seldom mature when the pycnidia first appear through the ruptured epidermis. Even in pycnidia that are known to be several months old most of the spores are still pale if not actually hyaline. All stages in complexity of pycnidial structure are to be found (text-figs. 3, 4, 5). They may be simple, papillate, and more or less spherical, with the free surface perhaps a little flattened. Two or more may occur in a row or group and have their walls in contact. In the next stage of complexity, in which more pycnidia are usually present, the walls in contact are replaced by common walls, each pycnidium still having its own ostiole; a rudimentary or a well-developed stroma may or may not be present in this stage. In the final stage, which occurs in the largest pycnidial groups, the combined pycnidia are replaced by a stroma with a single locule, one or more ostioles, and one, several, or no partial dissepiments.

The simplest non-stromatic isolated pycnidia are to be found wherever pycnidial formation is only beginning. Later, adjoining these pycnidia, or

in the region close by, stromatic pycnidia and chambered stromata are formed in close juxtaposition. An old row or group of pycnidia exhibits



FIGS. 3, 4, 5.—Pycnidia in different stages. In fig. 3 the pycnidium is single and has no stroma. In fig. 4 the pycnidia form part of a small group, and the beginning of a stroma is indicated in the area marked with parallel lines. In fig. 5 the pycnidia are part of a long row. A stroma is present, and one pycnidium is of the stromatic type with a single locule and a partial dissepiment. × 48.
FIG. 6.—Spores, young. × 352.
FIG. 7.—Spores, mature. × 352.

at one time every grade of pycnidial development, the one basal stroma being common to all the pycnidia of the group, with the exception of the

simplest younger ones, which in the ranked arrangement occur usually at either end of the row, and in the group arrangement at the periphery. Even for the youngest isolated members of any group, however, it is usually only a matter of time before they too are linked to the main body of the group by an extension of the common stromatic base. As already mentioned, this stromatic linking has not been found on the cones, where the pycnidia as a rule remain isolated from one another. The smaller size and the isolation of the cone-pycnidia are probably due to the greater hardness of the cones preventing the free ramification of the mycelium evident in the cortex of stem and branch, where, moreover, the hyphae are in direct communication with the water-supply of the xylem.

The size of the pycnidia varies from 250 × 250 to 800 × 800 micromillimetres. If they are prevented by mutual pressure from expanding, their height exceeds their width. On the other hand, in the complex type with the locular stroma the width is usually increased, and may be several times as great as the height. The ostiole is shortly papillate. The cells composing the walls of the pycnidium are, on the whole, thin-walled, angular to rounded, black on and near the surface, fuliginous in the intermediate region, quickly paling to hyaline in the interior.

The spores (pycnospores) are ellipsoid-obovate to cylindrical; the ends are rounded, the lower one being usually narrower than the upper, at times markedly so. The colour of mature spores is fuliginous to fuscous, but they may be discharged when immature, in which case the colour is often not deeper than a golden-fuliginous. The septation varies. In each row or group of pycnidia there are many in which only the non-septate *Sphaeropsis* type of spore is to be found, but if the material is kept until some of the pycnidia approach maturity, which may mean for several months. the older pycnidia show at least a small number of uniseptate spores. In certain cases the septate *Diplodia* type of spore can readily be found, but this is rare except when the material had been kept for a considerable time. As a rule it is unusual to find the septate spore in pycnidia on the cones, where the *Sphaeropsis* type predominates instead. Spores when mature range in size from 24–37 × 14–18 micromillimetres, the average being about 32–35 × 14–16 mmm. The sporophores are hyaline, and rather stout, attaining a size of from 7–12 × 2·5–3·5 mmm., with an average of 10 × 3·5 mmm.

Nomenclature.—The above description closely approximates that given by Kickx for *Diplodia pinea* (Desm.) Kickx* occurring on needles of *Pinus montana* and *P. silvestris* in France, Belgium, and Italy. Kickx, and Karsten also, reported a form of the same fungus in the bark of *P. silvestris* and of species of *Abies*. The only major point of difference between the fungus of Kickx and the present one is that Kickx, and also Desmazière, who originally described it, failed to notice the locular stromatic type of pycnidium occurring on stem and branch when the fructifications are advanced in age. But as the material described was on needles, that in the cortex being only noticed in passing, the significance of the omission is lessened, especially as the stromatic type does not occur regularly in the present disease. Moreover, it is only within the last few years that the stromatic type has been recognized to be a usual phase in the development of the more common *Sphaeropsis* or *Diplodia* phases; and, as Desmazière first described his organism as long ago as 1842, the omission of these

* As given in Saccardo, *Syll. Fung.* vol. 3, p. 359, 1884.

characteristics of the pycnidium is not surprising. Recently von Hoehnel has claimed that a fungus known earlier as *Phoma macrosperma* Karst. is merely *Diplodia pinea* (Desm.) Kickx at the stage when its spores are still hyaline. More recently again, Petrak, after insisting on the validity of the genus *Botryodiplodia* for members with grouped pycnidia and spores over a certain size, gave a detailed description of *Phoma macrosperma* Karst., adding to it details of structure which had not been given in the original description, and including in particular a greater spore-size than had been given for *Diplodia pinea* (Desm.) Kickx. This discrepancy he has overlooked, or has perhaps considered it insignificant (seeing that this character may show considerable variation), and, on the strength of his own previous assertions concerning the validity of the genus *Botryodiplodia*, has transferred *Diplodia pinea* (Desm.) Kickx to *Botryodiplodia pinea* (Desm.) Petr. Since then, although the generic limits of the Diplodiae are being more closely examined as knowledge of the developmental variations exhibited by members of the group is acquired, the genus *Botryodiplodia* as Petrak understands it still stands unchallenged.

The fungus attacking *Pinus radiata* and *P. muricata* in New Zealand is therefore referred to *Botryodiplodia pinea* (Desm.) Petr.

CONTROL OF THE DISEASE.

As the fungus as a rule works downwards from the tip of the stem or branches, control of the disease requires only the removal and destruction of the parts infected. The mycelium may reach some inches below the fructifications, and also below the lowest sign of unhealthiness in the tree; and the cut should therefore be made about 2 ft. below the lowest sign of the disease, the cut surface being then protected from parasites by a coating of Stockholm tar.

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Three Fungous Diseases of *Salix* in New Zealand, and some Saprophytic Fungi found on the same Hosts.

By B. Jean Murray, B.Sc., Assistant Mycologist, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 27th August, 1924; received by Editor, 5th December, 1924; issued separately, 6th March, 1926.*]

Plates 8–11.

Among the commonest and most beautiful shade and ornamental introduced trees in the Nelson district are willows of both the "weeping" (*Salix babylonica*) and "crack" (*Salix fragilis*) varieties. For some time it has been noticed that several diseases, probably of fungous origin, are becoming prevalent on many of these trees. In February, 1923, an investigation was commenced upon these diseases. It was found that, though in some cases both species of willow were attacked by the same fungus, the worst disease of each host was caused by a different fungus—*e.g.*, by *Marssonina* on the weeping-willow and *Macrophoma* on the crack-willow.

On material collected for examination from many different localities from Wakapuaka to Tasman numerous saprophytic fungi were also found.

Three of the worst diseases of the willows in this district, and the fungi causing them, are described in the present paper, and notes on a number of the saprophytic fungi found on the same hosts are included.

Marssonina salicicola (Bres.) P. Magn. on *Salix.*

The most serious disease is caused by the fungus *Marssonina*, which, though it occurs on both species of *Salix*, is chiefly found on *S. babylonica.* The parasite attacks the tree with great vigour, causing considerable injury and loss, and throughout the Nelson district practically no tree of this species has escaped infection. Many have lost branches and are dying.

(In April, 1925, since this paper was in print, specimens of the disease on *Salix babylonica* were collected in Ward, Marlborough.)

The disease was also noticed by the writer in a mild form on weeping-willows at Mitcham, South Australia, in January, 1924, and at Aldgate, South Australia, in January, 1925.

Pathological Changes in *Salix babylonica.*—The effect of the parasite on this host is most noticeable. In trees which are only mildly attacked the leaves become covered, principally upon the lower surface, with pale reddish-brown spots which have a purple tinge when fresh; a few brown cankers may be seen on the twigs. When badly diseased the tree almost completely loses its "weeping" habit; the leafy branches, instead of being long and pendulous, are much shorter and tend to grow more upright, until, at a distance, the tree might almost be mistaken for one of the upright varieties (Plate 8).

This effect on the host is due to the shortening of the internodes in the diseased "weeping" branches, the average distance between any adjoining two of the ten nearest the tip in a number of diseased branches being 0·8 cm., as compared with 2·4 cm. in an equal number of healthy specimens. This leads to an increase in the number of twigs, which are produced closer

together and are shorter. Weeping branches may be 1 m., 1·5 m. long, or more, while on badly attacked trees there may be no true weeping branches, but in their place a number of small twigs, a few to 30 cm. long, bearing leaves at fairly crowded nodes. The twigs become distorted with cankers, and tend to curl upwards.

When the twig is first infected a small black elliptical spot appears upon it, which rapidly spreads (Plate 9, fig. 1). Upon this spot whitish acervuli are produced beneath the epidermis of the host, which they raise and finally rupture, setting free the hyaline two-celled spores. As the infected tissue of the twig dies, it dries, cracks, and is broken off by another layer of spores developing below. In this manner several layers may crack off in succession. The canker spreads along and round the twig, and may join other cankered areas, until a large part is involved (Plate 9, fig. 2). The infected leaves become covered with spots, described on pages 60 and 61 (see Plate 9, fig. 3). On badly diseased twigs the leaves, all of which are often infected to some extent, are usually very much smaller than those on healthy branches, averaging 5·9 cm. in length as compared with 12·5 cm. Instead of hanging pendulous against the twigs, they tend to curl and grow more at right angles to it; this is often due to infection of the petiole, causing it to blacken and shrivel. The midrib may also be infected, when elliptical or elongated black spots appear similar to those on the young twigs and petioles. The stipules are often attacked as the leaves unfold, when they drop off at a very early age, while normally they remain at the base of the leaf long after it is mature. Eventually the leaves become yellowish, and fall prematurely. It was observed in early spring that the young leaves were infected immediately on the opening of the leaf-buds (Plate 9, fig. 4), infection probably being caused by spores from cankers upon the living twigs of the tree, from bud-scales (Plate 9, fig. 5), and from dead leaves which had been diseased the season before and remained on the ground. Examination of these during the winter and early spring showed numerous acervuli still producing a large quantity of spores.

Spots similar to those on the leaves, bearing typical acervuli and spores, were also found on the catkins of the weeping-willow.

Pathological Changes in *Salix fragilis*.—The same fungus as the above occurs on the crack-willow, but much more rarely, and then with less disastrous effect. Blackened areas may be formed along the young twigs, and cankers are sometimes produced on the older ones; but the main effect is seen on the leaves, which become thickly covered on the upper surface with dark-brown or black circular or irregular spots, which differ from those on the weeping-willow by being smaller and more numerous. On the lower surface of the leaves of the crack-willow faint small reddish-brown irregular spots may sometimes be seen; these at times become confluent. The spots are more numerous on the upper surface of the leaf than on the lower. They produce acervuli and spores similar to those on the weeping-willow.

IDENTITY OF THE FUNGUS.

Genus.—The fungus under discussion was named *Marssonia* by Fischer in 1874. But, as P. Magnus (1906, p. 88) pointed out, this name had already been used for the genus *Marssonia* Karst. of the Gesneriaceae, so he altered it to *Marssonina* P. Magn., under which title the genus is now known.

Rabenhorst, Saccardo, Engler and Prantl, and other authorities classify *Marssonina* P. Magn. (= *Marssonia* Fisch.) as being "exclusively found parasitic on leaves," and thus distinguish it from the similar genus *Septomyxa*, which is "saprophytic on stems and fruit." But Diedicke (1913, p. 540) observed that this was not an accurate basis of classification, as species of *Marssonina* had been found on twigs also. He suggested that a more exact distinction would be made by limiting *Septomyxa* to those species with a stromatic conical acervulus in which the production of conidiophores occurs typically on the side of the acervulus, and by extending *Marssonina* to include twig-infecting forms with a flat subepidermal acervulus bearing conidiophores over the basal disc.

In the present instance the identity of the fungus upon the leaves of the willow with that upon the twigs, as is exhibited in the similarity of general appearance, shape of the acervulus, and shape, size, and structure of the conidia, serves to confirm Diedicke's statement as to the identity of leaf- and twig-inhabiting forms.

Species.—The only mention of a *Marssonina* on the twigs of the willow is made by Fukushi (1921, p. 1), who found a disease in Japan which he thought was "probably due to *Marssonina*." If this should prove to be so, it may be found to be the same species as that occurring on the twigs of the willow in New Zealand. Furthermore, the local species does not agree with the single species of *Septomyxa* recorded on this host. As for the species of *Marssonina* found on the leaves, the present species does not agree in all respects with any recorded on the willow, though strongly resembling three.

The Fungus on Salix babylonica.

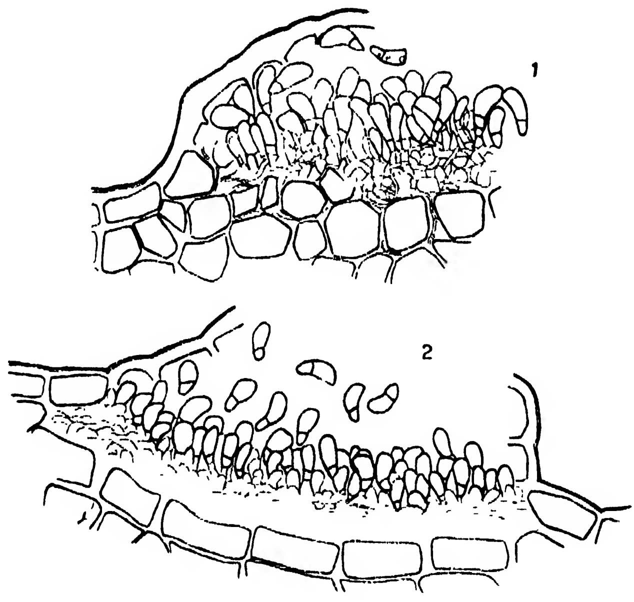
The spots may be on either surface of the leaf, but are principally on the lower surface, where they are circular, not sharply outlined, up to 1 mm. in diameter, light purplish-brown (reddish when dry), at first scattered, then crowded and confluent until in many cases the whole lower surface of the leaf is covered (Plate 9, fig. 3). Where present on the upper surface the spots are smaller, dark-brown, and scanty. Upon the spots are numerous white acervuli. These are at first circular, often becoming confluent, varying in size from 60 to 210 mmm.,* the average size when mature being between 150 and 200 mmm., lifting up and breaking through the epidermis and exposing the conidia on very short hyaline conidiophores, which are produced over the surface of the flat acervulus. The acervulus may be slightly sunken in the centre, due to the collapse of the dead host cells below. The conidia are club- or pear-shaped, frequently curved, two-celled, the lower cell being much the smaller of the two, hyaline, contents granular or guttulate, 11–16 mmm. long by 3–7 mmm. broad (text-fig. 1). On the young twigs (text-fig. 2) the acervuli of the first layer formed subepidermally are similar to those on the leaves, but as the canker develops, splitting the cortex and producing new acervuli on the successive surfaces exposed, the acervuli are more irregular in shape and size. Throughout, however, the spores are identical with those on the leaves.

As mentioned, there are three species of *Marssonina* that distinctly resemble the species under consideration—*e.g.*, *M. salicicola*, *M. rubiginosa*,

* In this article the contraction "mmm." is used for micromillimetres.

and *M. nigricans*. Briefly stated, the species found differs from *Marssonina salicicola* (Bres.) P. Magn. in the spots on the leaves being amphigenous, principally hypophyllous, and in having some spores smaller; from *Marssonina rubiginosa* (Ell. & Ev.) P. Magn. in the spots on the leaves not being "more definite on the upper surface," and in often having larger spores which are not always acute below; and from *Marssonina nigricans* (Ell. & Ev.) P. Magn. in having larger spots on the leaves, the spots not being edged with a narrow tawny margin, and in the acervuli being numerous and white.

The species of *Marssonina* found upon *Salix* in Nelson agrees in all important features with *Marssonina salicicola* (Bres.) P. Magn., and is therefore referred to that species, in spite of the spots on the leaves being described as "epiphyllous," whereas in the Nelson specimens they are amphigenous.



FIGS. 1, 2.—*Marssonina salicicola* (Bres.) P. Magn. on *Salix babylonica* L. Sections through an acervulus with spores. Fig. 1, on leaf; fig. 2, on young twig. × 330.

This species has hitherto been recorded only upon the leaves of willows, but it is most probable that in the present instance the diseases of leaves, twigs, and catkins are caused by the same fungus. The acervuli and spores produced are identical on the different parts of the tree. Slight differences in the size and colour of the spores can easily be accounted for by the differences in host-tissue in the different parts of the tree.

Marssonina salicicola on the leaves in New Zealand varies according to the species of willow upon which it is found. When occurring on *Salix babylonica* it varies towards *Marssonina rubiginosa*, the reddish-brown spots being more numerous on the lower surface, though the spores are usually larger than in *M. rubiginosa* and not always acute below. When it occurs on *Salix fragilis* it varies towards *Marssonina nigricans*, the spots

being blackish and more numerous on the upper surface of the leaves, but the acervuli produced are neither scanty nor dark as they are in *M. nigricans*. However, in the two cases, on *Salix babylonica* and *Salix fragilis*, the acervuli and spores resemble each other so closely that it is doubtless the one species of fungus occurring on both willows, the variation mentioned being due to the different hosts.

Since the three species resemble one another so closely, it will probably be found that *M. rubiginosa* and *M. nigricans* are merely variant forms of *M. salicicola*, the variation being dependent, as in the species under discussion, upon the species of *Salix* upon which they occur.

The fungus found in Nelson upon the different parts of both *S. babylonica* and *S. fragilis* is therefore referred to *Marssonina salicicola* (Bres.) P. Magn.

Macrophoma Salicis Dearn. & Barth. on *Salix fragilis.*

One of the more important fungus diseases of the crack-willow (*Salix fragilis*) in this district is caused by a species of *Macrophoma*. It was first noticed on the 8th February, 1923, at Appleby, and subsequently at Wakapuaka, Atawhai, and Nelson.

Effect on Host.—The infected leaf becomes discoloured at the tip. This discoloration, reddish-brown in hue, soon spreads over the upper end of the leaf, being somewhat sharply limited by a straight or semicircular line from the adjoining tissue, which, however, becomes rather yellow, showing that the fungus is encroaching and the cells dying. Examination of this brown tip shows very minute blackish-brown swellings, which indicate the position of the pycnidia (Plate 11, fig. 2). The tip of the leaf dies and becomes dry, as later does also the whole of the infected area, the remainder of the leaf becoming yellow, falling prematurely. Trees with this disease lose all their leaves when uninfected trees are still green (Plate 10).

It was noticed that the leaves on trees infected with *Macrophoma* were as a rule much smaller than those on uninfected trees, frequently being only from one-half to one-third the size. This may be due directly to the presence of the fungus, or indirectly to premature defoliation due to the disease weakening the vigour of the tree in previous seasons. It is quite common to see a branch every leaf of which has a reddish-brown tip (Plate 11, fig. 1).

On some of the tips of both living and dead leaves infected with *Macrophoma*, *Pleospora herbarum* was also found.

Identity of the Fungus.

The pycnidia of the fungus are distributed more or less densely, are very minute, 100–170 mmm. broad, globose or flattened-globose, deeply sunken in the tissue of the leaf, amphigenous, having a short broad papilla, which slightly raises the epidermis and opens by a circular pore, wall somewhat thin, concolorous with the dying tissue of the leaf, hyaline inside ; spores (pycnospores) oblong with rounded ends, continuous, hyaline, granula, 16–20 × 6–8 mmm. (most 20 mmm. long), sporophores short, about 6 mmm. long, filiform. Parasitic on living leaves of *Salix fragilis*.

No record has been found of any species of *Macrophoma* parasitic on any part of the willow or saprophytic on the dead leaves. Of the

several species recorded as saprophytic on dead wood of various *Salix* sp., the one found here most resembles *Macrophoma Salicis* Dearn. & Barth., in the description of which, quoted below, the points of dissimilarity to the *Macrophoma* in question are printed in italics.

" *Macrophoma Salicis* Dearn. & Barth., *Myc.*, vol. 9, 1917, p. 352.

> " Pycnidia thickly distributed, sometimes gregarious or seriate, cortical, rupturing the epidermis in *a cleft or stellate manner*, 0·25–0·5 mm. in height and diam. Ostiola thick, short *or longer up to 0·3 mm.* Conidia hyaline, continuous, *ovoid* to oblong or *fusoid*, 12–16 mmm. × 6·9 mmm. *On dead twigs of Salix exigua* Nutt., Billings, Montana."

It will be seen that the species found in Nelson differs from *Macrophoma Salicis* chiefly in the smaller size of its pycnidia, in lacking the (only occasionally) greater length of ostiole, and in the manner in which the pycnidia rupture the epidermis of the host. But in many cases in which a fungus occurs on different parts of a tree it is usual to find considerable variation in the size of the fungus fructifications according to the part in which they are formed, the pycnidia formed on leaves being smaller, as a rule, than those on twigs or branches of the same tree. Similarly, in pycnidia in which the ostiole is developed only until it reaches the surface of the host, as in

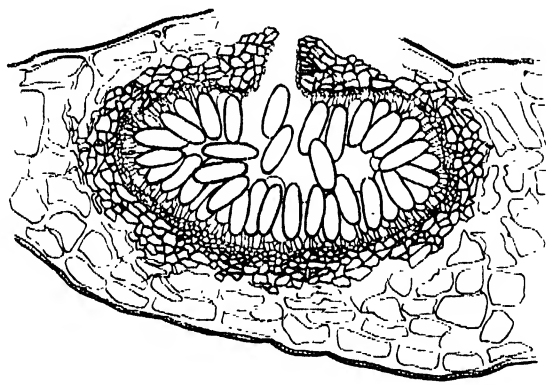


FIG. 3.—*Macrophoma Salicis* Dearn. & Barth. on leaf of *Salix fragilis* L. Section through a pycnidium with spores. × 300.

the present case, it is to be expected that the length of the ostiole would, on the whole, be shorter in pycnidia formed on thin leaves than in those formed on a branch, where they may occasionally be more deeply buried. The manner of the rupture of the host surface as the pycnidia push through is again largely a local peculiarity, dependent chiefly on the arrangement of the resistant or less-resistant kinds of host-tissue in the immediate vicinity of the pycnidia, and also to a certain extent on the manner of grouping of the latter—*i.e.*, whether they are in groups or series, and whether scattered or dense.

Of greater significance is the difference in size, and sometimes in shape, of the spores; but as spore sizes in common occur in the two sets of material, and as there is no other species of *Macrophoma* on the willow

which resembles so closely that found in Nelson, the latter is regarded as *Macrophoma Salicis* Dearn. & Barth. occurring parasitically, instead of saprophytically, as previously recorded.

Gloeosporium Capreae Allesch. on *Salix fragilis.*

A species of *Gloeosporium* on *Salix* was found by the writer in Nelson on the 21st February, 1923. This is the commonest fungus growing parasitically on the crack-willows (*Salix fragilis*) in this district, and it also occurs infrequently on *Salix babylonica.*

Effect on Host.—The fungus occurs only upon the leaves, forming upon the upper surface small round or irregular somewhat raised spots, greyish-white with a narrow dark-brown margin, varying from 0·5 mm. to 2 mm. in diameter, very often confluent and forming large irregular patches often up to 1·5 cm. long and exceptionally to 3·5 cm.; sometimes, especially when large and near the margin or tip of the leaf, a large part of the diseased area may drop away from the leaf; there is a tendency for the blotches to follow the veins of the leaf, so that long narrow patches may frequently be found along the midrib and larger veins (Plate 11, fig. 3). The spots are covered with minute black dots where the acervuli break through the cuticle. The under-surface of the leaf becomes discoloured with dark-brown areas corresponding to the spots above, but the acervuli are borne principally upon the upper surface.

Identity of the Fungus.

The acervuli are crowded, brown, small, 80–120 mmm. in diameter, often confluent, in which case they are larger, erumpent, lifting up and breaking through the cuticle; conidiophores light-brown, 15–20 × 1–2 mmm., bearing small oblong to oval, hyaline, one-celled conidia, 5–12 × 3–6 mmm., often 2-guttulate (text-fig. 4).

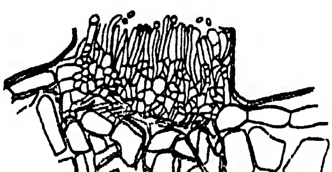


Fig. 4.—*Gloeosporium Capreae* Allesch. on leaf of *Salix fragilis.* Section through an acervulus with spores. × 330.

Gloeosporium Salicis West. is the most common species on the willow occurring in America and Europe. The descriptions of this species given by Saccardo (*Syll. Fung.*, 3, p. 711) and Rabenhorst (Bd. 1, Abt. 7, p. 500) are very scanty, but Potebnia (1910, p. 77) published a more detailed account describing two kinds of spores, macroconidia 14–16 × 5–7 mmm. and microconidia 4–5 × 0·5–1 mmm., while Dearness (1917, p. 360) gives the spore range as 15–23 × 7·5–10 mmm. The spores are usually slightly

[W. C. Davi

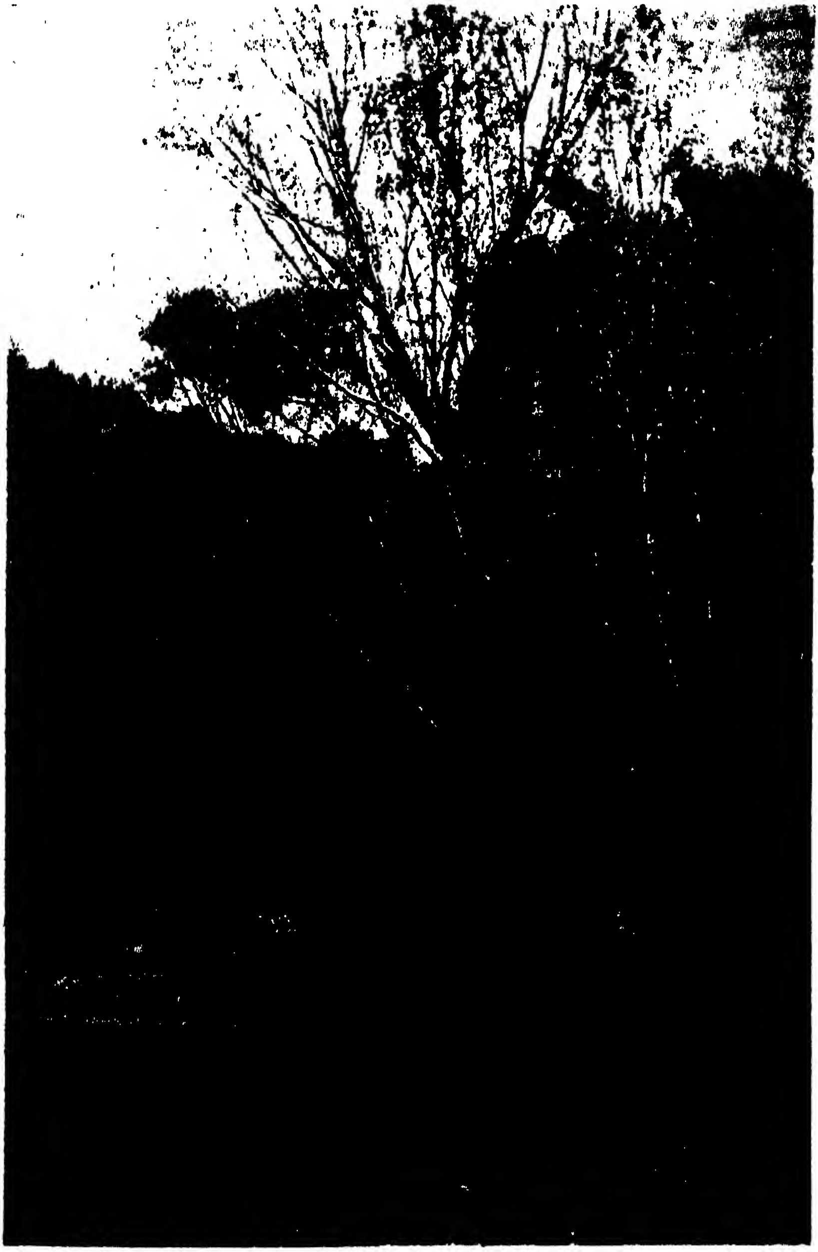
ıg-willow (*Salix babylonica* L.) badly dis *arssoı na s ıicicola* (Bres.) P. Magn. Note loss of "weeping" habit, except in bı righ han , which is still more or less normal.

Face p. 64.]

[W. C. Davies, photo.

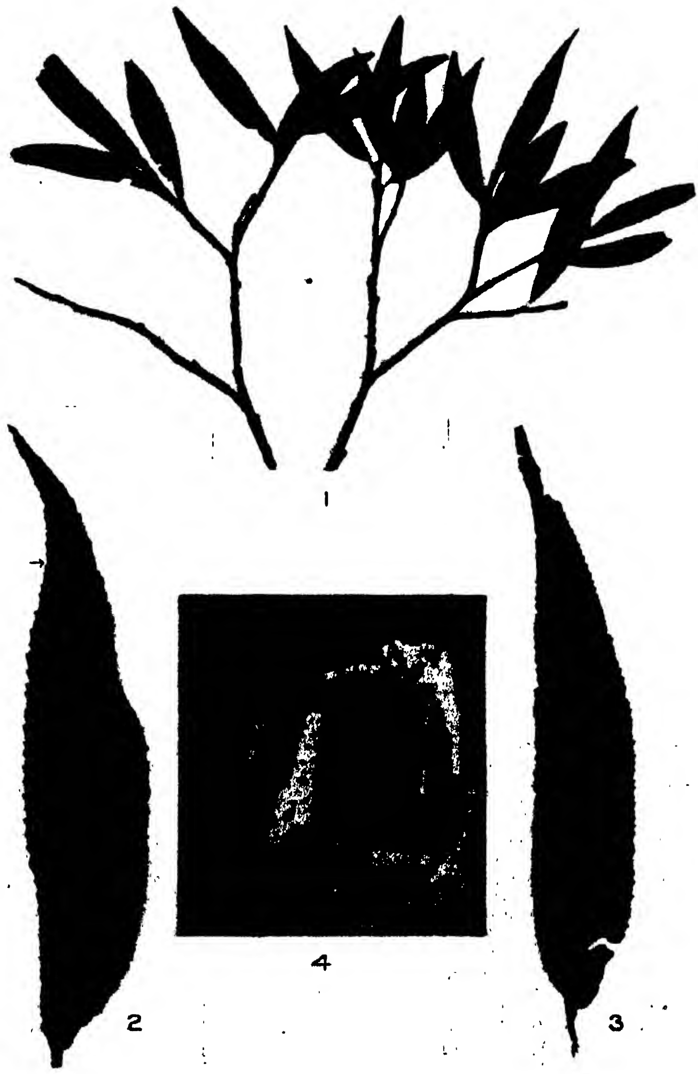
Marssonina salicicola (Bres.) P Magn. on *Salix babylonica* L.

FIG. 1.—Dark spots on young twig producing the first acervuli.
FIG. 2.—Older twig covered with cankers.
FIG. 3.—Lower side of leaf covered with spots.
FIG. 4.—Young twig showing the stage of first infection, which takes place immediately after the opening of the buds.
FIG. 5.—Part of twig in fig. 4 enlarged to show infected bud-scales and canker on the stem, from which infection of the young leaves has probably taken place.



[*W. C. Davies, photo.*

Macrophoma Salicis Dearn. & Barth. on a crack-willow (*Salix fragilis* L.) which is losing all its leaves early, while a healthy crack-willow in the left background is still green.



[W. C. Davies, photo.

FIG. 1.—*Macrophoma Salicis* Dearn. & Barth. killing tips of leaves of *Salix fragilis* L. The small round spots scattered over the leaves are caused by *Gleosporium Capreae* Allesch.
FIG. 2.—*Macrophoma Salicis* Dearn. & Barth. on tip of leaf of *Salix fragilis* L. An arrow indicates the position of some of the numerous small pycnidia in the infected area.
FIG. 3.—*Gleosporium Capreae* Allesch on leaf of *Salix fragilis* L. Note the tendency of the pustules caused by the fungus to follow the veins of the leaf, and of the diseased areas to fall away from the leaf. The minute black dots on the blotches indicate the acervuli.
FIG. 4.—*Gnomonia bullata* n. sp. on dead twig of *Salix babylonica* L. On the surface of the twig may be seen the pustules caused by the beaks of the perithecia raising and piercing the epidermis. The round bases of the perithecia, some of which are dry, showing the concave manner of collapsing, are exposed on the underside of the bark, which has been partially stripped off; while the depressions left by them may be seen on the wood.

curved and form short curved white cirri. In all these points this common species differs from that which occurs in the Nelson district, while, on the other hand, a less common species, *Gloeosporium Capreae* Allesch., is very similar.

Gloeosporium Capreae Allesch. (Sacc., *Syll. Fung.*, 14, p. 1010.)

Spots epiphyllous, large, indeterminate, covering almost the whole leaf, brownish-grey then becoming pale; acervulus epiphyllous, minute, in dense clusters of various shapes, covered by the epidermis, fairly often confluent, black; conidia oblong, straight or slightly curved, obtuse at both ends, hyaline, continuous, often guttulate, varying in size, 6–16 × 2–4 mmm.; conidiophores narrowed above, hyaline, continuous, 15–20 × 1–1·5 mmm.

On still-attached or fallen leaves of *Salix Capreae*, Munich, Bavaria.

If this diagnosis is compared with that given for the local species it will be seen that they differ in two points. In the first place, the conidiophores in the local species are light-brown in colour; and, in the second place, while the measurements of conidia of average size coincide in the two cases, those at the extreme of the range tend to be longer and narrower in *Gloeosporium Capreae*. The fact that the latter species occurs on *S. Capreae*, while the local species was found on *S. fragilis* and *S. babylonica*, suggests that the difference may be due to the effect of the different hosts. The coincidence in the size of the average conidia of the fungus in the two cases, and the fact that, although there is colouring in the conidiophores of the local species, it is not deep, suggest that these variations are not sufficient to justify the exclusion of the local species from *Gloeosporium Capreae*.

Fukushi (1921, p. 1) has recorded a disease of *Salix purpurea* var. *angustifolia* in Japan due to *Physalospora Miyabeana* n. sp. and its conidial form *Gloeosporium*. No *Physalospora* has been found in connection with the local species, nor have any twigs been seen here with the cankers which are so marked a feature of the disease in Japan. The appearance of the spots on the leaves caused by the Japanese species differs from that of the species found here. Also, the latter, on the whole, agrees more closely with *Gloeosporium Capreae* Allesch., as which species, therefore, it is, in the opinion of the writer, to be regarded.

Gnomonia bullata n. sp.

Perithecia black, scattered or more often gregarious (occasionally two perithecia may be found with the beaks united), sunken in the bark, which when wet may be stripped off the wood, carrying with it the globose perithecia, the round shining black bases of which are then exposed, the bases contracting inwards when drying (Plate 11, fig. 4); beak straight or bent, 100–390 mmm. long × 230–330 mmm. broad, narrowed above, perforating the periderm and raising the epidermis to form a little round pustule through which the tip of the beak projects (text-fig. 5), thickened and swollen flask-shaped below, consisting of small blackish compressed angular cells which are smaller and arranged in parallel-fibred structure bordering the central canal, which is usually bent spirally or may be straight; wall of the perithecia of two layers, the outer consisting of several rows of blackish angular thick-walled cells, the inner of several

rows of thin-walled hyaline parenchymatous cells which are often compressed laterally (text-fig. 6).

Asci 70–100 × 12–17 (most 14–16) mmm., clavate, narrowed at the apex, sharply attenuate below, having in the young ascus a long filiform stalk which in the mature stage breaks off or becomes swollen and shortened though usually still basally attenuate; wall of ascus very thin, except at the apex, where it is thickened and opens by a pore, 8-spored, distichous; paraphyses absent (text-fig. 7).

Spores oblong-elliptical, some obtusely rounded at both ends, others somewhat rounded-fusoid, straight, more often unequal-sided or slightly curved, uniseptate, slightly constricted by the septum which is at or near the centre, hyaline, 16–23 × 5–7 mmm., contents granular or guttulate.

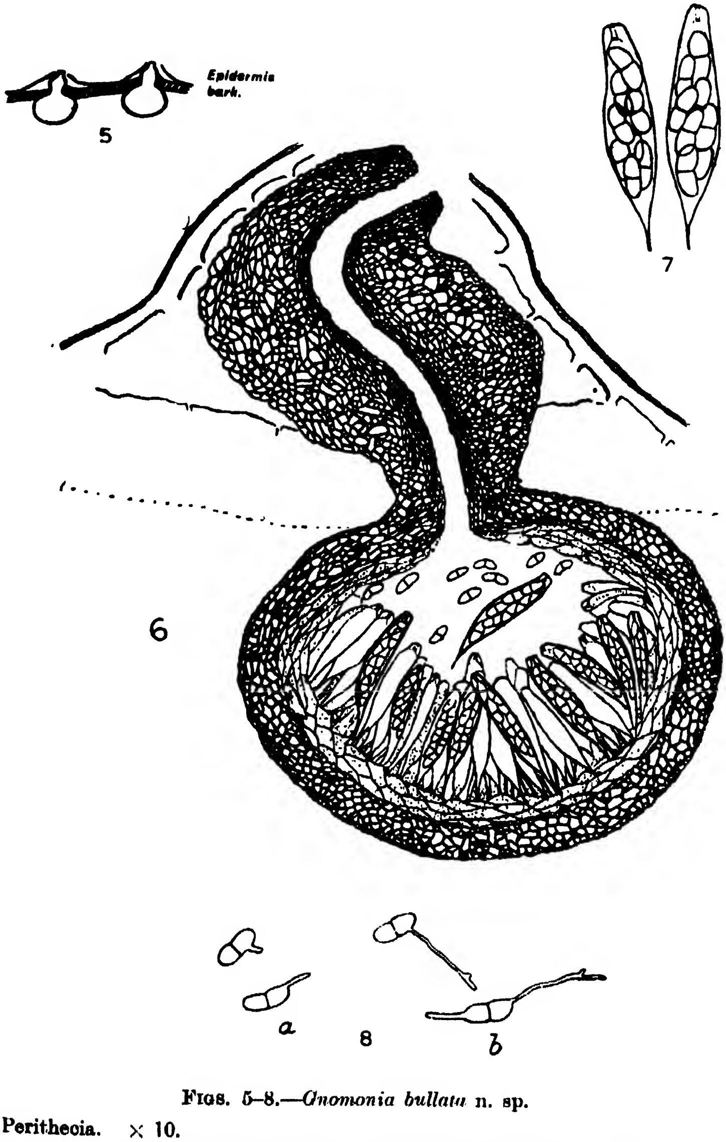
On dead twigs and branches, still attached, of *Salix babylonica* and *Salix fragilis*, Nelson, 15th September, 1923.

Throughout the district this is one of the commonest saprophytes occurring upon dead twigs and branches still attached to the trees, particularly on those twigs which have died the season before. It occurs more frequently and abundantly upon the weeping-willow than on the crack-willow.

Species.—The species differs markedly from *Gnomonia pleurostyla* Auersw., the one species of *Gnomonia* recorded by Saccardo (*Syll. Fung.*, vol. 1, p. 569) for the willow. *G. pleurostyla* is found on dead leaves; the asci are six-spored, the spores filiform lance-shaped, 50–55 × 2 mmm. Winter, in Rabenhorst's *Krypt. Fl.* (1887, p. 589), gave *G. apiculata* (Wallr.) Wint. on the willow, but expressed a doubt as to whether the species really belonged to this genus; and later Petrak (1921, p. 176) showed that it was identical with a species of *Cryptodiaporthe* on *Populus*, and that it should therefore be called *Cryptodiaporthe apiculata* (Wallr.) Petr. Petrak (1921, p. 180) has also transferred *G. salicella* (Fr.) Shroet. to *Cryptodiaporthe salicella* (Fr.) Petr. E. M. Doidge (1924, p. 56) records *Gnomonia* sp. upon *Salix* sp. in South Africa, but gives no diagnosis and does not state the species. Moesz (1918, p. 60) describes *G. salicina* n. sp. upon dead branches of *Salix alba*. Unfortunately, this paper is not available. These are the only records of species of *Gnomonia* found upon *Salix*, and a comparison with the other species of *Gnomonia* found on different hosts shows that the species found here does not agree entirely with any of them, and in the absence of Moesz' paper it seems justifiable to separate it as a new species.

Relationship to other Fungi.—As this fungus so frequently occurs on dead still-attached twigs which were infected with *Marssonina* the season before, the question arises whether this may be the ascigerous stage of the fungus of which *Marssonina* is the conidial stage. This is not unlikely, as Klebahn (1905, p. 336) has demonstrated by cultures and ascospore infection the connection between *Gnomonia leptostyla* and *Marssonina juglandis* (on the bitter-nut *Juglans cinerea*). On the other hand, other species of *Gnomonia* have been shown to have different conidial forms, chiefly *Gloeosporium*, *Asteroma*, and *Leptothyrium*. Of these genera, *Gloeosporium Capreae* has been found on Nelson willows. According to Klebahn (1918, p. 317), the conidial forms of *Gnomonia* belong to the Melanconiaceae, so either *Marssonina salicicola* or *Gloeosporium Capreae* may prove to be the conidial form of *Gnomonia bullata*.

The fungus germinates very readily in water (four hours), (text-fig. 8), in nutrient agar (turnip, willow, &c.), and in a solution of soluble substances



FIGS. 5–8.—*Gnomonia bullata* n. sp.

5. Perithecia. × 10.
6. Perithecium (type with bent beak); epidermis and bark indicated. × 120.
7. Asci. × 330.
8. Spores germinated in water—(*a*) after four and a half hours, (*b*) after eight and a half hours. × 330.

from the willow. Healthy cultures of vegetative growth were readily obtained and watched to see if conidial stages would be produced, with a view to proving whether or no this *Gnomonia* were connected with the *Marssonina* so common on the same trees, or with the *Gloeosporium* common on *Salix fragilis*. So far none of the cultures have produced spores. It is also intended to undertake inoculation experiments to see if one of the parasitic diseases may be produced by this common saprophyte.

Petrak (1921, pp. 176, 180) has proved that several recognized species of *Gnomonia* belong to the genus *Cryptodiaporthe*, and the question arises whether the one under consideration may also belong to the latter genus, as in some cases two perithecia were found with their beaks partially or completely joined and having a common mouth, and there is always a marked thickening round the beak, which suggests the possibility of a rudimentary stroma, of which, however, there is no other sign. A great quantity of material has been available, and careful examination has not furnished any evidence in favour of this view. Except in the instances mentioned, perithecia were separate, although crowded; the type of perithecium and the structure of the ascus have the marked characteristics of *Gnomonia*, in which genus the fungus has been placed.

SOME SAPROPHYTIC FUNGI FOUND ON THE WILLOWS IN THE NELSON DISTRICT.

SPHAERIALES.

Cryptodiaporthe salicella (Fr.) Petr.

Dead twigs of *Salix fragilis*. Toitoi Valley, Nelson, 25th October, 1923.

(?) *Leptosphaeria Salicinearum* (Pass.) Sacc.

Dead leaves of *Salix babylonica*. Nelson, 20th June, 1923.

Leptosphaeria Salicinearum is the only species of this genus recorded on willow-leaves, but no measurements of asci or spores are given in its description. The specimens found here agree essentially with Saccardo's description on such points as he mentions. The spores are distichous, 3-septate, not or hardly constricted, fusoid, mostly curved, 16–29 × 4–7 mmm., yellowish or light olive. The local species is placed tentatively under *Leptosphaeria Salicinearum* (Pass.) Sacc., although lack of detail in the description given by Saccardo prevents final confirmation.

Metasphaeria orthospora Sacc.

Dead wood, *Salix babylonica*. Wakapuaka, 3rd July, 1923; Maitai Valley, 10th August, 1923.

Dead wood, *Salix fragilis*. Maitai Valley, 17th August, 1923.

The spores of the local specimens are more constricted at the median septum, but not at the other two septa, than in those described by Saccardo.

Pleospora herbarum (Pers.) Rabh.

Dead fallen leaves, *Salix babylonica* and *Salix fragilis*. Common throughout the Nelson district.

Dead tips of living leaves of *Salix fragilis*, the tips having been first killed by *Macrophoma Salicis*. Appleby, 8th February, 1923.

SPHAEROPSIDALES.

Macrophoma Salicaria (Sacc.) Berl. & Vogl. (Text-fig. 9.)

Common on dead twigs, *Salix babylonica.* Wakapuaka, 12th February, 1923.

Common on dead twigs, *Salix fragilis.* Maitai Valley, Nelson, 12th September, 1923.

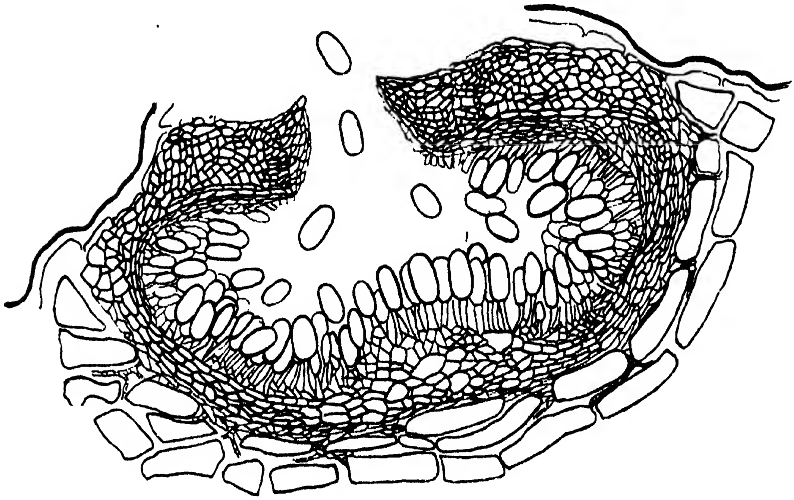


FIG. 9.—*Macrophoma Salicaria* (Sacc.) Berl. & Vogl. on dead wood of *Salix babylonica.* Section through pycnidium with spores. × 240

Diplodia salicina Lev.

Dead twigs, *Salix babylonica.* Maitai Valley, Nelson, 21st September, 1923.

Dead twigs, *Salix fragilis.* Toitoi Valley, Nelson, 19th September, 1923.

The range of spores was 20–28 × 10–13 mmm. The *Sphaeropsis* stage was often present.

MELANCONIALES.

Coryneum Salicis Togn.

Decaying leaves, *Salix fragilis.* Appleby, 1st July, 1923.

Dead twigs still attached to the tree. Toitoi Valley, 19th September, 1923.

The specimens found differ from the type in having in most cases only the lower cell pale, the upper being the same colour, fuliginous, as the middle cells.

Hyaloceras Saccardoi (Speg.) v. Hoehn. (Text-fig. 10.)

Dead twigs and leaves of *Salix babylonica.* Appleby, 8th October, 1923.

As the only species of this genus recorded on *Salix* is *Hyaloceras excipuliformis* Bubak, which differs from the species found in Nelson in general appearance and in having only three septa and smaller spores, while the local species agrees with the description of

Hyaloceras Saccardoi (Speg.) v. Hoehn. upon *Quercus* except in the smaller details of measurement of cilium and stalk, the local species is therefore referred provisionally, because of the lack of relationship between the two hosts, to *Hyaloceras Saccardoi* (Speg.) v. Hoehn.

The measurements of the Nelson specimens are as follows: Conidia 16–22 × 6–7 mmm. (most 18–20 mmm. long), 4-septate, constricted; one cilium 12–24 × 0·5–1 mmm. on upper cell; persistent conidiophore 20–30 × 0·5–1 mmm.

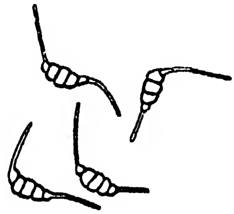


FIG. 10.—Spores of *Hyaloceras Saccardoi* (Speg.) v. Hoehn. on *Salix babylonica*. × 330.

Pestalozzia funerea Desm.

Dead twigs, *Salix babylonica*. Nelson, 19th September, 1923.

As the local specimens of *Pestalozzia* differ markedly from the species of that genus already recorded for the willow, while they have all the characteristics of the common species *Pestalozzia funerea* Desm., they are referred to that species, which, although occurring on a wide range of hosts, has not hitherto been recorded on *Salix*.

The writer's thanks are due to Dr. Curtis, of the Cawthron Institute, for assistance and advice, and to Mr. Davies, of the Cawthron Institute, for the photographs.

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A New Genus of the Hysterangiaceae.

By G. H. CUNNINGHAM, Mycologist, Department of Agriculture, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 1st October, 1924; received by Editor 31st December, 1924; issued separately, 6th March, 1926.*]

WHILE collecting in the Whakatikei Reserve, Paekakariki, Wellington, Mr. and Mrs. J. G. Myers obtained abundant specimens of a peculiar white fungus, which they handed to the writer for identification. On examination this species proved unique, and calls for a detailed description of its structure.

The plants were found growing on rotting wood partially buried in the humus of open grassy places in the forest. Specimens are white in colour, and vary greatly in size and shape. The most characteristic feature is the presence of numerous sterile lobes, springing from the dorsal surface of the peridium. These lobes are dull-white, and may be clavate, capitate, or fan-shaped, solitary or branched, and are at their bases attached to a common pulvinate or globular body, the peridium. This also is white externally, and is attached to the substratum by several coarse white rhizoids.

When a mature plant is sectioned longitudinally the lobes are seen to be sterile and frequently hollow, the gleba being present only in the basal portion or peridium to which the lobes are attached. The function of these lobes is unknown. The gleba may extend for some little distance into their base. It is olivaceous in colour, and is traversed by numerous stout trabeculae, which arise from a distinct sterile basal disc. It is gelatinous in consistency, as is the greater portion of the interior of the lobes.

STRUCTURE OF THE MATURE PLANT.

Peridium.—This consists of two layers, an outer thin cortex or exoperidium, and a thick, gelatinous endoperidium. The exoperidium consists of a layer, 0·5–1 mm. thick, of loosely-woven, intricately-branched, colourless hyphae. The hyphae of which it is composed remain distinct during the lifetime of the plant, and at no time are gelatinized, nor do they assume the form of a pseudoparenchyma. This layer surrounds the endoperidium. The outer few layers of hyphae are somewhat evanescent, and give to the plant a pruinose appearance.

The endoperidium lies within the exoperidium, and is sharply delimited from it. It consists of a thick (3–5 mm.) layer of hyphae, which in the mature plant is partly gelatinized. It forms the whole of the internal portion of the lobes. At the base it forms a pulvinate sterile disc (basal disc), from which arise numerous stout trabeculae, which tend to divide the gleba into numerous locules.

Gleba.—This is traversed by the trabeculae, which give off secondary branches, which in turn are divided until an intricately-branched network of tramal plates is produced, the spaces between being occupied by lacunae lined with the hymenium. The lacunae are minute irregular spaces, closely compacted together save in the centre of the plant, where they are less crowded, and are frequently separated by large irregular interspaces. The

tramal plates consist of a central gelatinized layer (often absent near the terminal ends of the ultimate branches), with a layer on either side composed of small polygonal cells—the subhymenium—bearing on their proximal surfaces basidia closely compacted into a palisade tissue. The basidia are long, cylindrical, frequently branched, and each bears, on short, almost obsolete sterigmata, eight elliptical continuous spores. The spores are minute, hyaline, and uninucleate.

Development.

As a sufficiency of developmental stages has not been obtained, the account given below is incomplete, and in consequence somewhat disconnected.

Developing plants first become noticeable as minute globular nodules on the upper surface of the rhizoids. Sections at this stage show the whole to consist of loosely-woven hyphae. When the plant has attained to a size of 3–4 mm., differentiation of the different tissues commences. The plant at this stage is globular, save where it is attached at the base, where it is slightly flattened. A definite exoperidium is marked off through the remainder of the internal tissues becoming more compacted. In the latter a more compact zone of hyphae appears near the base: from it strands of compacted hyphae arise, differentiation proceeding in an upward and outward direction until several primary trabeculae are formed. These are partly surrounded by irregular and poorly-defined lacunae, due, no doubt, to rupture of the hyphae in the vicinity. Next, branches are given off from the trabeculae, and in turn these branch so that the loosely-woven network of the gleba is formed. Within the margin of these branches small lacunae arise, and around the inner surfaces of these appear the subhymenial cells, which soon give rise to basidia. No specimens have been obtained showing the first formation of these lacunae, so that it is not known whether the formation of the regular hymenium is preceded by production of occasional basidia from irregular scattered papillae, as in *Gallacea* (1924). Growth of the trabeculae and smaller branches continues in this manner until a well-developed gleba is produced, this tissue appearing in plants of a diameter of 6–7 mm.

Later lacunae form within the peripheral zone (here termed the "endoperidium") lying beneath the exoperidium. Gelatinization of the trabeculae, central portions of the tramal plates, and endoperidium commences shortly after glebal differentiation, until at maturity all the glebal tissue, save spores, hymenium, and subhymenium, is gelatinized.

Development of Lobes.—These do not appear until glebal differentiation is well begun. They arise as small outgrowths from the dorsal portion of the endoperidium, and enlarge until they appear as distinct clavate or capitate bodies. They arise from the portion of the endoperidium immediately underlying the exoperidium, and are thus in all probability not derived from potentially sporogenous tissue. While still small they may again produce secondary and even tertiary lobes. Lobes may arise from any part of existing lobes, but generally arise from the vicinity of their attachment with the peridium. In large specimens the lobes become hollow, but no further stage of development than this has been observed. The plants are indehiscent, spores being released by gradual decay of the plant.

As no plants possessing these peculiar lobed structures have been described, the writer believes the genus to be undescribed, and proposes to name it *Phallobata*, on account of its phalloid-like spores and basidia, and the lobed character of the peridium.

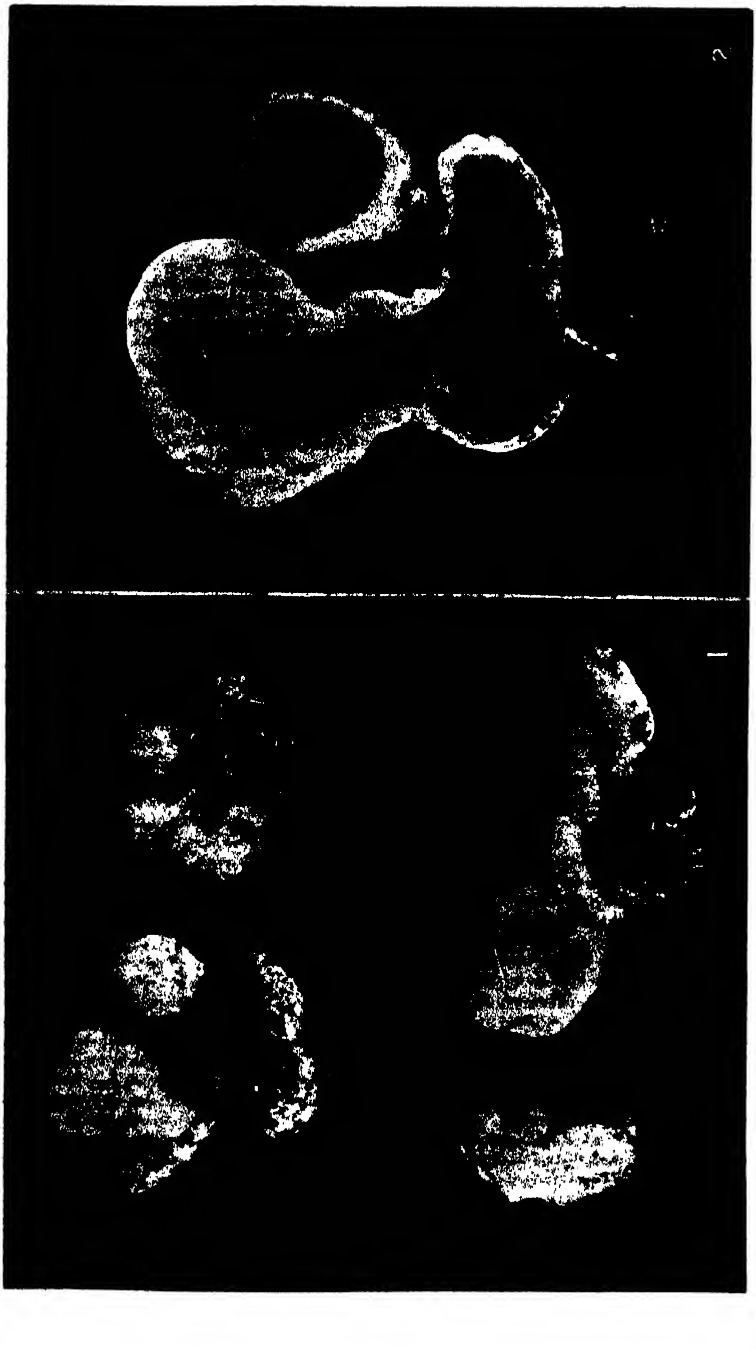

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FIG. .—Selected plants, ural size: showing iations in size and lobes so c— —ıcı ristic of the genus.

FIG. .—Section of ı × 2: showing struc of lobes and gleba.

[G. H. Cunningham, photo.

Section of plant, × 6: *en*, endoperidium; *ex*, exoperidium; *l*, sterile lobed portion; *bas*, sterile base; *tr*, trabecula.

PHALLOBATA n. gen.

Peridium sessile, indehiscent, variously shaped, crowned with 1–several large single or branched sterile lobes; of two layers—an external loosely-woven intricately-branched layer of hyphae (the exoperidium), and an inner thick gelatinized layer forming the body of the lobes; attached to the substratum by numerous coarse rhizoids.

Gleba permanent, consisting of numerous anastomozing gelatinized tramal plates, enclosing minute lacunae, divided by several stout trabeculae springing from a sterile base into several loculae; hymenium lining the free surfaces of the tramae. Basidia 8-spored, subclavate or cylindrical, branched; spores borne on short slender sterigmata (or subsessile), continuous, hyaline or tinted, smooth, uninucleate. Cystidia and other aberrant cells absent.

Habitat: Saprophytic upon decaying wood.

Phallobata alba n. sp.

Peridium white or greyish-white, depressed-globose, globose, elliptical, or tuberous, up to 30 mm. wide, 35 mm. high, crowned with 1–several sterile lobes: attached to the substratum by numerous coarse white rhizoids. Lobes springing from the apical portion of the peridium, cylindrical, clavate, capitate, pulvinate, or irregular, white, smooth or rugose, pruinose, dry, frequently hollow within.

Gleba olivaceous, traversed by numerous gelatinized hyaline trabeculae, arising from the sterile pulvinate basal disc, enclosed within the broad gelatinized endoperidium. Lacunae elliptical, ranging in size from 0·1 mm. to 2 mm. or more.

Spores smooth, continuous, almost hyaline, rounded at both ends, 2-3 × 1 mmm.

Habitat: Gregarious on rotting wood in grassy places in the forest.

Distribution: Forest reserve, Whakatikei, Paekakariki, Wellington, 45 m.; *J. G. Myers, Mrs. Myers!* 2nd June, 1924. *J. C. Neill! J. G. Myers!* 16th June, 1924.

Type collection. Herb. No. 1187.

SYSTEMATIC POSITION OF THE GENUS.

The earlier stages of development and glebal characters would place the genus in the family Hysterangiaceae, as defined by Fisher (1900). The 8-spored branched basidia and subsessile minute uninucleate spores would place it in the Phallales. It more closely resembles the genus *Phallogaster* Morg. than any other, but is separated on account of its being indehiscent, and in the possession of the queer lobes, so characteristic a feature of the plant. This genus, together with *Phallogaster*, would serve as a connecting-link between the Phallales and the Hysterangiaceae, and for this reason should be placed in an intermediate family. As such does not exist, it is retained in the Hysterangiaceae for the present.

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FISCHER, ED., 1900. Hymenogastrineae in Engler and Prantl. *Nat. Pflanzenfam.*, 1**, pp. 296–313.

Third Supplement to the Uredinaceae and Ustilaginaceae of New Zealand.

By G. H. Cunningham, Mycologist, Department of Agriculture, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 1st October, 1924; received by Editor, Editor, 31st December, 1921; issued separately, 6th March, 1926.*]

UREDINACEAE.

ADDITIONAL SPECIES.

The collecting of the following species adds a fourth family to the Uredinaceae of New Zealand.

CRONARTIACEAE.

Teleutosori subepidermal. Teleutospores unicellular, catenulate, apedicellate, united laterally into columns or pulvinate masses; epispore coloured or hyaline, smooth; basidium external. Uredosori with or without peridia. Uredospores catenulate or borne singly on distinct pedicels. Aecidia present or absent.

This family, although not recognized by certain workers, is, I believe, sufficiently characterized by the catenate teleutospores to warrant retention. Sydow (*Mon. Ured.*, vol. 3, p. 502, 1915) places *Chrysomyxa* and *Barclayella* in the Chrysomyxeae, a subfamily of the Melampsoraceae.

Chrysomyxa Unger.

Ung., *Beit. verg. Path.*, p. 24, 1840.

Melampsoropsis (Schroet.) Arth., *Res. Sci. Congr. Bot. Vienne*, p. 338, 1906.

Heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones immersed, flask-shaped.

I. Aecidia erumpent, with definite peridia. Aecidiospores globose to elliptical; catenulate; epispore hyaline, covered with coarse deciduous warts; germ-pores indistinct or wanting.

II. Uredosori with or without peridia, pulverulent, erumpent; peridia, when present, delicate, evanescent. Uredospores catenulate, apedicellate; epispore hyaline, verrucose; germ-pores indistinct.

III. Teleutosori erumpent, waxy, pulvinate, becoming velvety. Teleutospores catenulate, in simple or branched chains, unicellular, elliptical; epispore hyaline, smooth, thin; germ-pore apical, obscure.

Distribution: Europe; Asia; North America; India.

The aecidia, when present, occur on species of *Picea*; the uredo- and teleuto-spores on *Empetrum*, *Pyrola*, *Rhododendron*, and *Ledum*.

The uredospores occur in chains, and peridia may be present or absent; when present they are usually evanescent and difficult to detect, save when sections are made through nearly mature sori. Between the uredospores *in situ* large interstitial cells are present. The teleutospores are catenulate, and become compacted into pulvinate sori. They germinate without a period of rest, giving to the sori a characteristic velvety appearance.

1. **Chrysomyxa Rhododendri (DC.) de Bary.** **Ericaceae.**

DB., *Bot. Zeit.*, p. 809, 1879.

Uredo Rhododendri DC., *Fl. Fr.*, vol. 6, p. 86, 1815.
Caeoma Rhododendri Link., *Sp. Pl.*, vol. 2, p. 16, 1825.
Coleosporium Rhododendri Schroet., in Cohn's *Beitr.*, Bd. 3, Heft 1, p. 56, 1879.

0. Spermogones amphigenous, flask-shaped, honey-yellow.

I. Aecidia hypophyllous, seated on elongate yellow spots. Peridium irregular, laterally compressed, 0·5–3 mm. long, 0·25–0·75 mm. high, margins hyaline, lacerate. Spores globose, subglobose, or elliptical, 20–44 × 14–20 mmm.* (Sydow); 17–45 × 12–22 mmm. (DB.); epispore hyaline, closely and finely verruculose, save for a smooth longitudinal strip along one side; 2–2·5 mmm thick; germ-pores indistinct.

II. Uredosori hypophyllous, seated on discoloured spots which are visible on the upper surface, minute, 0·2–0·5 mm. diam., circular or irregular, bullate, solitary, or more frequently in scattered groups of 3–15 or more, orange-yellow, ruptured epidermis inevident; peridium delicate, evanescent, hyaline. Spores catenulate, interstitial cells evident, obovate, elliptical or subglobose, 18–26 × 15–21 mmm.; epispore hyaline, closely and finely verruculose; 2–2·5 mmm. thick; cell contents orange-yellow, granular, with one prominent central nucleus; germ-pores indistinct.

III. Teleutosori hypophyllous, seated on small discoloured spots which are visible on the upper surface, minute, 0·2–0·5 mm. diam., circular, pulvinate, brownish-red, ruptured epidermis inevident. Spores catenulate, chains 80–130 mmm. long, shortly cylindrical or prismatic, 20–30 × 10–14 mmm.; epispore hyaline, smooth, 1 mmm. thick, with an annular thickening at the summit of the uppermost cell; germ-pore apical, obscure.

Host: *Rhododendron* sp. cult. On leaves. Herb. No. 1636. II. Stratford, Taranaki, *W. Pettigrew!* 4 Nov., 1924.

Distribution: Europe; Asia.

This species has been introduced from Europe with the host. Only the uredo stage has been collected, and the determination has been made from this. It agrees closely with the published descriptions and with the uredo stage of herbarium specimens in the possession of the writer.

The aecidia occur on *Picea excelsa* and *P. obovata* in Europe, the uredo- and teleuto-spores on numerous species of *Rhododendron*. The life-cycle is but imperfectly known; the teleutospores germinate in early summer, producing basidiospores which may infect the leaves of *Picea*. The resultant aecidiospores may infect *Rhododendron* leaves, and in these the mycelium apparently overwinters, producing uredo- and teleuto-spores the following summer.

PUCCINIACEAE (TRIBE PHRAGMIDEAE).

KUEHNEOLA Magnus.

Mag., *Bot. Centr.*, vol. 74, p. 169, 1898.

Autoecious. Cycle of development includes 0, II, III.

0. Spermogones subcuticular, flattened, hemispherical.

II. Uredosori erumpent, pulverulent, without peridia; of two kinds, primary and secondary. Primary uredosori usually associated with the

* In this article the contraction "mmm." is used for micromillimetres.

spermogones, aparaphysate; secondary uredosori frequently paraphysate. Uredospores borne singly on distinct pedicels; epispore rough, hyaline; germ-pores equatorial (?), obscure.

III. Teleutosori erumpent, aparaphysate. Teleutospores divided by transverse septa into 3–several cells; epispore coloured or subhyaline, smooth: germ-pores solitary, apical; pedicels hyaline, short, fragile.

Distribution: Europe; North and South America; India.

Members of this genus are in Europe confined to the Rosaceae, but in North and South America they occur in addition on the Malvaceae. The solitary New Zealand species has been introduced with the host.

The teleutospores characterize the genus, and appear as if several single teleutospores of some coronate species of Uromyces were superimposed one upon another, the lowest being attached by the pedicel to the sorus.

1. **Kuehneola albida** Magnus, *l.c.* Rosaceae.

Chrysomyxa albida Kuehn, *Bot. Centr.*, vol. 16, p. 154, 1883.
Uredo Muelleri Schroet., *Krypt. Fl. Schles.*, vol. 3, p. 375, 1887.
Phragmidium albidum Lagerh., *Mitth. Bad. Bot. Verh.*, p. 44, 1888.
Kuehneola Uredinis (Link.) Arth., *N. Am. Fl.*, vol. 7, p. 186, 1912.

0. Spermogones epiphyllous, in small groups, seated on discoloured spots, depressed-globose, 0·1–0·2 mm. diam.

II. Primary uredosori epiphyllous, surrounding the spermogones, in crowded groups, 0·5–1·25 mm. across, usually somewhat elongate, often arranged in a circinate manner, bullate, pulverulent, orange-coloured, fading to pallid cream, surrounded by the ruptured epidermis. Secondary uredosori hypopyllous and caulicolous, frequently seated on discoloured spots which are visible on the upper surface, scattered, or more frequently in crowded irregular groups, circular, small, 0·1–0·5 mm. diam., bullate, pulverulent, lemon-yellow, bleaching to a pallid cream-colour with age, aparaphysate. Spores elliptical, obovate, or more rarely subglobose, 20–30 × 17–24 mmm.; epispore hyaline; moderately and bluntly echinulate, 1–1·5 mmm. thick; cell-contents lemon-yellow, vacuolate; germ-pores indistinct (probably 3 or 4, equatorial—Arthur).

III. Teleutosori hypophyllous, scattered or in small groups, circular, 0·2–0·5 mm. diam., pulvinate, tinted yellow, ruptured epidermis inevident. Spores 5–13-celled, commonly 5–6, cylindrical or cylindrical-clavate, 85–110 × 18–24 mmm., each cell 17–40 × 15–24 mmm., trapezoidal, somewhat coronate above; epispore thickened from below upwards, 1·5 mmm. below, apex 3–5 mmm., hyaline or tinted yellow, smooth; pedicel persistent (or wanting), short, hyaline, delicate; germ-pore solitary, situate in one of the projections at the apex of each cell.

Host: *Rubus fruticosus* L. On leaves and stems. Herb. Nos. 246, 1637.

II. Tokomaru, Wellington, *G.H.C.*, 6 Dec., 1920. Kauri Gully, Auckland, *G.H.C.*, 2 Mar., 1921. Helensville, Auckland, *E. Bruce Levy!* 3 Feb., 1921. Opotiki, Auckland, *M. Davey!* 25 Oct., 1920. Te Puke, Auckland, *R. Waters!* 18 Feb., 1922. Wairoa, Hawke's Bay, *E. H. Atkinson!* 12 Oct., 1924.

Distribution: Europe; North America.

The uredo stage only has been collected in New Zealand; this, in a previous paper (*Trans. N.Z. Inst.*, vol. 54, p. 690, 1923), was in error referred to *Gymnoconia Peckiana*, the caeomata of which it resembles closely. Dr. B. O. Dodge (United States Department of Agriculture,

Washington), to whom specimens were submitted, wrote pointing out this error, and in addition forwarded material for comparative purposes. On examination and comparison of the specimens of *Kuehneola albida* kindly forwarded by Dr. Dodge with New Zealand material I find the two to be identical. *Gymnoconia Peckiana* should therefore be deleted from the record of Uredinaceae occurring in New Zealand.

ADDITIONAL HOSTS.

Puccinia pedatissima G. H. Cunn. (*Trans. N.Z. Inst.*, vol. 54, p. 673, 1923).

Host: *Ourisia macrocarpa* Hook. f. Herb. No. 1633. On leaves. III. Roaring Creek, Arthur Valley, Otago, *E. H. Atkinson!* 18 Jan., 1920.

This host is endemic and confined to the South Island (Cheeseman, *Fl. N.Z.*, p. 549, 1906).

Puccinia Elymi Westnd. (*Trans. N.Z. Inst.*, vol. 55, p. 1).

Host: *Bromus sterilis* L. Herb. Nos. 1638, 1639. On leaves. II–III. Roadside, Ashburton, Canterbury, *J. C. Neill!* 18 Oct., 1924.

This host is an introduced plant, common throughout the agricultural areas of New Zealand.

USTILAGINACEAE.

ADDITIONAL SPECIES.

TOLYPOSPORIUM Woronin.

Wor., *Abh. Senck. Nat. Ges.*, vol. 12, p. 577, 1882.

Sori forming a granular spore-mass at maturity, usually in the inflorescence, commonly in the ovaries, formed of numerous spore-balls. Spore-balls consisting of few or many spores, opaque, dark-coloured, permanently united, sterile cells absent.

Spores bound together by ridged thickenings or folds of the epispore, dark-coloured, irregular in shape, smooth or roughened on their free surfaces; germination similar to that of *Ustilago*.

Distribution: Europe; Asia; North and South America; Ceylon; India; Africa; Australia.

The following endemic species is the only one that has been collected in New Zealand. The genus is fairly well represented in Australia, for McAlpine (*Smuts Aus.*, p. 186, 1910) records seven species. Species of the genus are confined to the Gramineae, Cyperaceae, and Juncaceae. The genus is characterized by the very firm spore-balls, their dark colour, and the union of individual spores by folds of the epispore. It is separated from *Thecaphora* by the more compact nature of the spore-balls, and chiefly on account of the much darker colour; from *Sorosporium* in the balls being permanent, although in this latter genus certain species occur in which the balls are also permanent. In such a case they are separated by the presence of (in *Tolyposporium*) the peculiar ridged folds of the epispore.

1. **Tolyposporium littorale** n. sp. (Fig. 1.) Cyperaceae.

Sori in ovaries, usually destroying all in the inflorescence, concealed within the glumes, subglobose to elliptical, 1–2 mm. long, black, at first agglutinated in firm masses, becoming apparent only upon rupture of the

perigynium, when pulverulent and granular. Spore-balls of 20–50 or more spores firmly and permanently united by ridged folds, irregularly elliptical, subglobose or angular, 48–110 × 40–70 mmm., black, opaque.

Spores irregular in size and shape, obovate, cuneate, or angular, 15–25 × 14–20 mmm.; epispore dark brown, smooth on the united faces, covered with coarse deciduous tubercules on the free, 1–2 mmm. thick where smooth, up to 8 mmm. thick on free surface, often with lateral winged projections at margins of free surfaces.

Host: *Cladium Huttoni* T. Kirk. In ovaries. Herb. No. 1640. Sea-shore, Tauranga Harbour, Auckland, *J. C. Neill! G. H. C.*, 20 Jan., 1924. (Type.)

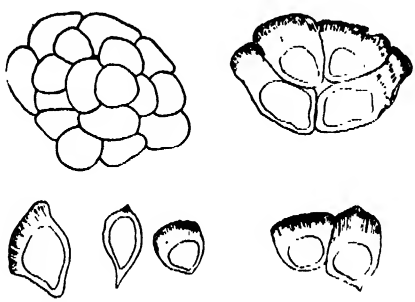

FIG. 1.—*Tolyposporium littorale* G. H. Cunn., on *Cladium Huttoni* T. Kirk: spore-ball (× 320) and spores (× 500).

The host is endemic and confined to the North Island, where it is apparently common on the margin of certain lakes (Cheeseman, *Fl. N.Z.*, p. 787, 1906).

I have been unable to germinate the spores. The spore-balls of this species are so firm that separation of the spores is not possible unless the balls are first boiled in lactic-acid solution, or treated for some time with caustic-soda solution. The spores appear as if covered on their free surfaces with large, irregular, deciduous tubercules, the crevices between giving to the spores a decidedly areolate appearance The spores are not unlike those of *T. lepidosperma* McAlp., in that they are thickened and much roughened on their free surfaces, but the spore-balls are quite distinct, being much larger in size, more irregularly angular in shape, and spores are much larger.

FARYSIA Raciborski.

In a former paper on the Ustilaginaceae of New Zealand (*Trans. N.Z. Inst.*, vol. 55, p. 414, 1924) the name *Elateromyces* Bubak was used for a genus characterized by the presence of "elaters" in the sori. I find that the name *Farysia* was used by Raciborski for a species (*F. javanica* Racib.) possessing this same character, and, as Raciborski's name has priority, the three species included in *Elateromyces* should be cited as under:—

FARYSIA Raciborski, *Bull. Acad. Sci. Cracovie*, p. 354, 1906.

F. nigra n. comb.
Syn. *Elateromyces niger* G. H. Cunn.

F. olivacea (DC.) Sydow, *Ann. Myc.*, vol. 17, p. 42, 1919.
Syn. *Elateromyces olivaceus* (DC.) Bubak.

F. endotricha (Berk.) Sydow, *l.c.*
Syn. *Elateromyces endotrichus* (Berk.) G. H. Cunn.

When in England recently I examined the type of this last species (Herb. Kew., No. 4748), and find that the description given in my former paper is inaccurate, the spores especially being wrongly described. The following amended description has been drawn up from the type specimen :—

Farysia endotricha (Berkeley) Sydow, *l.c.* (Fig. 2.) Cyperaceae.

Sori on peduncles and main axes of the inflorescences, *not* in ovaries, jet-black, compact, elliptical, up to 20 mm. long, 8 mm. wide; elaters short, up to 5 mm. long, stout, black, curled, giving to the sorus a decidedly velvety appearance.

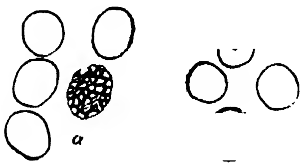

FIG. 2.—*Farysia endotricha* (Berk.) Syd.: *a*, spores from *Gahnia pauciflora* T. Kirk; *b*, spores from type material at Kew; both × 500.

Spores globose or shortly elliptical, 12–18 mmm. diam.; epispore dark-olivaceous or dark chestnut-brown, 1 mmm. thick, covered with numerous flattened irregular tubercules, the crevices between giving a distinct areolate appearance to the spores.

Hosts :—

Gahnia sp. On peduncles. Type: Herb. Berk., Kew, No. 4748. Auckland, *Sinclair!*

Gahnia pauciflora T. Kirk. On peduncles. Herb. No. 2190. Silverstream, Upper Hutt, Wellington, *H. Hamilton!* Jan., 1924.

The latter host is endemic, and not uncommon throughout both Islands (Cheeseman, *Fl. N.Z.*, p. 793, 1906). With this emended description it will be seen that the areolate nature of the epispore markings separates this from the other two species recorded from New Zealand. The figure given by Berkeley is inaccurate in that the elaters are much exaggerated, and the spores do not arise from them as his figure represents.

In the ***Farysia*** (*Ustilago*) *endotricha* folder at Kew (labelled "*U. trichophora* Kunze") are numerous collections. In working over these I found that only the type collection, consisting of one specimen from which Berkeley prepared his illustration, is of this species, all others being ***Farysia olivacea*** (DC.) Syd. This applies also to the "co-type" specimen of Cooke, which was acquired when his herbarium was bought by the Kew authorities.

ADDITIONAL HOST.

Ustilago Avenae Jens. (*Trans. N.Z. Inst.*, vol. 55, p. 405, 1924).

Host: *Avena sativa* L. In inflorescences. Herb. Nos. 1496, 1501. Tapanui, Otago, *J. C. Neill! G. H. C.*, 12 Feb., 1924. Winton, Southland, *J. C. Neill!* 15 Feb., 1924.

NOTE.

Urocystis Anemones = Tuburcinia Anemones.

In a recent paper Liro has shown, as a result of examination of the original material, that *Tuburcinia* Fries and *Urocystis* Rabh. are identical. As *Tuburcinia* has priority, this name should replace *Urocystis*. The genus should therefore be cited as under:—

TUBURCINIA Fries, *Syst. Myc.*, vol. 3, p. 439, 1832; and the species on p. 430 of my previous paper,—

T. Anemones (Pers.) Liro, *Ann. Univ. Fennicae Aboensis* ser. A, tom. 1, No. 1, p. 55, 1922.

Liro has split the original into several species; but to me, judging from the descriptions given, all are races of the one species.

Botanical Notes, including Descriptions of New Species.

By H. CARSE.

[*Read before the Auckland Institute, 25th November, 1924; received by Editor, 28th November, 1924; issued separately, 6th March, 1926.*]

PTERIDOPHYTA.

FILICES.

DURING recent years many alterations have been made by European pteridologists in the classification and nomenclature of ferns. As far as New Zealand genera are concerned, various species of *Aspidium* and one *Nephrodium* are now classed under *Polystichum*, the remainder of the *Nephrodia* and one *Polypodium* being known as *Dryopteris*. *Polypodium tenellum* is now *Arthropteris tenella*; *Davallia novae-zealandiae* is *Leptolepia*; *Asplenium umbrosum* is restored to its place as *Athyrium*; *A. japonicum* is *Diplazium japonicum*; *Lomaria* is *Blechnum*; and so on.

For some time I have been in correspondence with Dr. Carl Christensen, of Copenhagen, who is the European authority on ferns, and from his notes much of the following information is compiled. Quotations from his notes are followed by his initials (C. C.).

1. Dryopteris punctata C. Chr.

Syn. *Polypodium punctatum* Thunb. (*Manual*, 1008); *P. punctatum* var. *rugulosum* (Thomson).

"It is a true *Hypolepis*, not at all a *Dryopteris* as listed in my *Index*, where I followed Engler and Prantl. In the *Supplement to the Index* it is

placed under *Hypolepis*. The typical *Hypolepis punctata* is very different from your plant, which is *Polypodium rugosulum* Labill. (not *rugulosum*, as commonly spelled). . . . I call attention to the fact that the genus *Hypolepis* totally lacks true 'scales'—*i.e.*, flattened trichomes; the vestiture is always formed by *hairs*—*i.e.*, trichomes formed by one cell or a single row of cells. By this character *Hypolepis* may always certainly be known from *Dryopteris*." (C. C.)

2. **Dryopteris parasitica** (of New Zealand authors).

Syn. *Nephrodium molle* (*Manual*, 1006).

"The specimen sent [gathered at Kaitaia, North Auckland] resembles closely a common form widely spread in tropical countries. It is, however, scarcely typical *parasitica* (L.), and should probably be named *D. dentata* (Forsk.) C. Chr. The typical *parasitica* of Linnaeus is Chinese and, *inter alia*, characterized by the frond not being narrowed downward." (C. C.)

3. **Diplazium japonicum** Bedd.

Syn. *Asplenium japonicum* Thunb.

"The form from Kaitaia corresponds closely with the original description and figure of *D. congruum* Brack, and I do not hesitate to refer it to that species, but I am rather in doubt how it may be distinguished from *D. japonicum* . . . without having access to a large number of specimens from central Polynesia. I should prefer to name your form provisionally *D. japonicum*, suggesting that it is presumably that form described as *D. congruum* Brack." (C. C.)

There is another form occurring in the far north with longer pinnules which are more or less deeply toothed, and a form gathered at Te Whaiti, between Rotorua and Hawke's Bay, is still more deeply lobed. These Te Whaiti plants were gathered by Dr. Petrie and Mr. H. B. Matthews. A plant which they brought to Mr. H. B. Dobbie has developed pinnules more deeply lobed and a more open character. It appears to me to correspond very closely to the description of the late T. Kirk's *Asplenium umbrosum* var. *tenuifolium*. Dr. Christensen has not yet seen this form, but I hope to forward specimens to him shortly.

4. **Asplenium lamprophyllum** sp. nov.

Rhizoma breviter repens 7–10 mm. longum, vel densum, pallide viride, squamis paucis fugitivis. Stipes 15–20 cm. longus, teres, alte canaliculatus a parte superiore, a parte postica atro-purpureus. Frondes 10–55 cm. longae, 10–15 cm. latae, oblongo-lanceolatae, pallide virides, subacuminatae, supra lucentes, erectae, submembranaceae, bipinnatae; rhachides teretes, a parte superiore canaliculatae. Pinnae numerosae, 5·15 cm. longae, 2·5–5 mm. latae, lanceolatae a parte inferiore pinnatae, $\frac{3}{4}$ pinnatifidae; rhachis secundaria late alata. Pinnulae 15–30 mm. longae, late cuneatae, alte lobatae, lobis oblongis obtusis. Sori obliqui angusti 3–9 mm. longi, costis propinqui, raro prope margines.

A beautiful light-green brightly-shining fern, often growing in close masses 3–10 ft. in diameter. Rhizome shortly creeping, 7–10 mm. long, or stout and compact, pale green with a few scattered dark linear-lanceolate scales. Stipes 15–20 cm. long, terete, deeply grooved in front, usually

purplish-black and scaly at the back, green in front. Fronds 10–55 cm. long, oblong-lanceolate, slightly acuminate. light green, brightly shining on upper surface, erect, submembranous, bipinnate; rhachis terete, grooved in front, with a few deciduous scales. Pinnae numerous, ascending below, horizontal above, 5–15 cm. long, 2·5–5 cm. wide, lanceolate, sub-acuminate or acuminate, partly pinnate at base, the greater part pinnatifid: secondary rhachis broadly winged, with a few dark scales. Pinnules 15–30 mm. long, broadly cuneate, deeply lobed, lobes oblong, obtuse. Sori oblique, narrow, 3–9 mm. long, close to the midrib, seldom near the margin.

Habitat. — North Island: Maungataratara, Whangaroa County; Aponga, Maungatapere, Whangarei County; Great Barrier Island; vicinity of Auckland City; Mauku, Papakura (H. B. Dobbie!) Franklin County; Te Aroha, Piako County.

This fern has for many years been accepted as "a form of *Asplenium bulbiferum*." Not being satisfied with this determination, I submitted specimens to Dr. Christensen, who remarks: "This is a very interesting fern, and it is a wonder that till now it has escaped the attention of pteridologists, for it certainly is not *A. bulbiferum* . . . but a species of *Asplenium*, as far as I can see, undescribed. A close comparison of the specimens with several dried and living specimens of *A. bulbiferum* (in our Botanical Garden) show that scarcely one character is common to them. . . . I conclude, then, that it is an undescribed species. If you agree in this I think you will describe and name it."

Asplenium lamprophyllum usually occurs on or among rocks in shady woods; occasionally it is found on the lower parts of the trunks of trees, and sometimes on clay banks. Especially fine specimens are to be seen in the small woods among the lava blocks at Mount Wellington, near Auckland I have not yet seen specimens from farther south than Te Aroha. but probably it will be noted in other districts.

5. Blechnum capense (of New Zealand authors).

Syn. *Lomaria capensis* (*Manual*, 980); *L. procera* (Thomson's *Ferns*, 67).

"The three varieties received are certainly very interesting. A close study in the field is very necessary before finally deciding that these forms really belong to a single species. . . . Is your fern really conspecific with *Blechnum capense*, a South African fern? *B. capense* is said to be distributed over the whole Tropical and the South Temperate Zone, but I have little doubt that a comparative study based upon rich material will affirm my idea that several distinct species of more definite geographical range can be distinguished. This being the case, your fern should probably be named *B. procerum* (Forst.)." (C. C.)

6. Hypolepis.

"The three forms sent as *Hypolepis tenuifolia*, *H. Petrieana*, and *Dryopteris punctata* C. Chr. are as under:—

"(1.) *H. tenuifolia* Bernh.
"(2.) *H. punctata* (Thunb.) Mett. Syn. *H. Petrieana* Carse.
"(3.) *H. rugosula* (Labill.) J. Smith. Syn. *Dryopteris punctata* (see No. 1 of this paper).

"*H. punctata* differs from the other two in its pale, almost glabrous stipes and rhachises. Hooker and Baker united *H. punctata* and *H. rugosula* under *Polypodium*, hence comes this confusion." (C. C.)

Owing to this confusion, no New Zealand student of ferns appears to have been aware that *H. punctata* was indigenous. It was classed as "merely a form of *H. tenuifolia*." I was not satisfied with this view, so that when Dr. Petrie drew my attention more closely to this fern I did not hesitate to describe it as a new species (*Trans. N.Z. Inst.*, vol. 50, p. 64, 1918).

"*H. rugosula* is distinguished from *H. punctata* by its red rhachises and its viscosity." (C. C.)

Of *H. tenuifolia* there are at least two quite distinct forms, which may eventually have to be separated. One is a tall robust plant with a rhizome and stipe 10 mm. or more in diameter. The other is much smaller.

7. **Polypodium dictyopteris** Metten.

"Rhizome small, short, knot-like . . . emitting woolly rootlets, some of which creep and produce new tufts of fronds." (*Manual*, 81).

On lava rocks on the Auckland Isthmus the juvenile form of this fern produces a creeping rhizome 3–15 in. long, with tufts of fronds, or single fronds at intervals. As a rule by the time the plant attains maturity the long rhizome has disappeared, leaving the tufts or single fronds as separate plants.

Mr. J. W. Brame, of Aucklamd, who has devoted many years to the study of New Zealand ferns referring to this fern, writes,—

"Our last outing resulted in my obtaining a suite of specimens better than any I have before seen. Among them I have noted as follows :—

"(1.) Roots branching and producing single fronds or tufts of fronds at nodes of both main roots and branches of same ; these all juvenile. Roots upwards of 12 in. long.

"(2.) Two or more tufts of fronds connected by a root ; these both adult and juvenile.

"(3.) Adult or mature fronds, well spored, from 2½ in. to 14 in. long, and some of them 1 in. wide when fresh.

"(4.) In some instances fronds, instead of being 'tufted at top of rhizome,' seem to be produced in series, with short intervals between, along the rhizome, as in some of the dwarfed forms of *P. australe*."

8. **Gleichenia.**

"I call attention to my *Index Fil. Supp.* [113], where I, after examination of type specimen of *G. circinata* Sw. (Herb. Stockholm), have changed the names thus, and, no doubt, correctly :—

"1. *G. circinata* Sw. (1806), not authors. Syn. *G. dicarpa* R. Br. (1810).

"2. *G. microphylla* R. Br. (1810). Syn. *G. circinata* of authors.

"Your series should thus be named—

"1. *G. circinata* with its var. *hecistophylla*.

"2. *G. microphylla* (*G. circinata* of yours).

"May *G. alpina* be maintained as a distinct species ?" (C. C.)

Much confusion has been caused through the mixing-up of these two species, and many writers in New Zealand appear to infer that there are

great difficulties in distinguishing them. After a considerable amount of study in the field I find that they have very distinct characters which will enable the student to tell the one from the other almost at a glance.

The following are some of the main differential characters :—

	G. circinata (syn. *G. dicarpa*).	*G. microphylla* (syn. *G. circinata*).
Scales and hairs	Reddish-brown, often very dense	Dark reddish-brown, less dense.
Segments—		
Colour ..	Pale green, upper surface dull, usually very glaucous below	Dark green, upper surface polished, pale-yellowish below, less often glaucous.
Shape	Suborbicular, apex truncate or rounded, pouched	Triangular on a broad base, inner margin curved, giving apex an outward direction, apex subacute.
Sporangia	1–2, rarely 3, dull yellowish-white	1–4, rarely 5, bright shining-yellow.

Environment does undoubtedly affect the outward appearance of these two species, as suggested by Dr. Cockayne in *Some Noteworthy New Zealand Ferns*, p. 55. In the shade the pouch-like segments of *G. circinata* (formerly known to us as *G. dicarpa*) are almost flat, the scales and woolly hairs much less developed. But the shape remains. In *circinata* the segments are invariably suborbicular, in *microphylla* triangular with the inner side curved outwards; the sori of the former always show same with 2 sporangia of a dull yellowish-white, the latter almost invariably some with 4 sporangia of a bright-yellow hue.

The majority of writers on New Zealand ferns appear to infer that the type form of *G. circinata* Sw. (= *G. dicarpa* of authors) does not occur in the Dominion. This I have long held to be a mistake. When I sent specimens of what I took to be the type form and variety *hecistophylla* to Dr. Christensen he had no hesitation in recognizing the one as the type, the other as the variety. I sent specimens to the Sydney Botanic Gardens. Mr. E. Cheel, to whom they were submitted, writes: "The specimen of *G. circinata* marked 'Type?' seems to me to closely approach our Port Jackson plants of *G. dicarpa* R. Br., and may not be specifically different from that species, but the specimen labelled '*G. circinata* var. *hecistophylla* (A. Cunn.)' seems to me a well-marked form."

A specimen received from Sydney labelled "*G. dicarpa*" can readily be matched in this country, so that I think we may take it that *G. circinata* (*G. dicarpa* of authors) is here represented by the type plant and its two varieties.

G. circinata var. *hecistophylla* differs from the type in being smaller and more densely woolly. This seems to me to be the result of environment, as the variety is found in cold, sour land, exposed to sun and wind. The form known as var. *alpina* seems to pass by gradual steps from var. *hecistophylla*, some of the subalpine forms of which it is almost impossible to distinguish from *alpina*.

SPERMOPHYTA.

9. Lepyrodia Traversii F. v. Muell.

The habitat of this very local plant is given in the *Manual* as "Swamps between Hamilton and Ohaupo, middle Waikato district. Chatham Islands: Abundant in peaty swamps."

Since this was written the plant was discovered on a peat bog near Kaitaia, in the far north of Auckland.

Recently I found it occurring very plentifully in peat bogs at Tauhei, in the Morrinsville district, about twenty miles east from the Ohaupo Swamp. Here it was very much larger than I had seen it elsewhere. The *Manual* gives it "2–5 ft. high." The Tauhei plants, growing among tall *Leptospermum* scrub, are 4–10 ft. high, the stems being thick in proportion.

Lepyrodia will probably be extinct before very long. The Kaitaia Swamp has been drained and the plant is no longer seen. I understand that drainage and fires have destroyed the Ohaupo plants, and doubtless the same fate will shortly overtake those at Tauhei. It is more than probable that other colonies of *Lepyrodia* may exist among the thousands of acres of still undrained swamp in the middle Waikato area. The distribution of this plant at stations so widely separated as the Chathams, the middle Waikato area, and Kaitaia is noteworthy.

10. Pittosporum umbellatum Banks and Sol.

In woods near Whangaroa Harbour the leaves of juvenile plants are deeply ternately lobed, passing gradually on the upper part of the branch to the ordinary elliptic-oblong or lanceolate-oblong form. I have not noticed this heterophyllous form elsewhere.

In the same woods I found two mature trees, in fruit, on which the majority of the leaves are rather narrower than usual and are deeply lobed or bluntly toothed.

11. Pittosporum pimeleoides R. Cunn.

In *Trans. N.Z. Inst.*, vol. 53, p. 365, 1921, is an article on *P. cornifolium* A. Cunn. by D. Petrie, in which it is shown that that plant is in all probability unisexual, that the male flowers are produced in 6–8-flowered umbels, and that the female flowers are solitary or rarely in pairs.

In studying *P. pimeleoides* I find that the same thing occurs. The male flowers are produced in terminal umbels of 4–8 flowers, each flower on a long slender pedicel. The female flowers are solitary or in pairs on much shorter pedicels. It is to be noted that binate female flowers and capsules are much more common in this species than in *P. cornifolium*.

12. Pseudopanax Lessonii C. Koch.

In the *Manual* this species appears under the heading "Leaves of young plants not markedly different from those of old ones."

Some years ago the late Mr. Cheeseman told me he suspected there was a form of this plant (or possibly a distinct species) in which the juvenile leaves differ materially from the mature ones. Since then I have kept a lookout, and here give the result of my observations.

In the juvenile plants of what I take to be typical *P. Lessonii*, as described in the *Manual*, the leaflets hardly differ in shape from those of mature plants. In my specimens, from shrubs 2–5 ft. high, the leaflets are 2–4 in. long, rather more deeply toothed.

The other form is very different. In the mature state the leaves are usually 5-foliolate, leaflets oblong-lanceolate, linear-lanceolate, to linear-oblong, 3–6 in. long, more coriaceous than in the type form.

The juvenile form of this plant is often difficult to distinguish from the trifoliolate form of *P. crassifolium*, though, as a rule, the leaflets are less rigid.

The plants from which these specimens were obtained are 1–6 ft. in height, none showing signs of having flowered at any time. I have divided them into two sets—(*a*) those having 3–5 or 5–7 leaflets, and (*b*) those having 1–3 leaflets.

(*a*.) Shrubs 4–6 ft. high. Leaflets 3–5, 5, or 5–7, broadly or narrowly linear, 4–10 in. long, ½–1 in. wide, distantly, bluntly toothed, an incurved hook at the end of each tooth.

(*b*.) Shrubs 1–4 ft. high (possibly merely younger states of above). Leaflets 1–3, narrow linear, 3–10 in. long, ½–1 in. wide, toothed as in (*a*).

So far I have seen two only of this form in flower. My specimens were gathered in various places between the North Cape Peninsula and Coromandel Peninsula.

Mixed with these is a juvenile form which the late Mr. Cheeseman suggested to Mr. John Bishop, of Titirangi, might perhaps prove to be the Chatham Island *P. macrocarpa*.

13. **Dracophyllum Matthewsii** sp. nov.

Frutex *D. latifolio* A. Cunn. affinis, sed in partibus omnibus minor. Truncus ± 4·5 m. altus. Rami graciles non verticillate. Folia 10–30 cm. longa, 12–25 mm. lata. Panicula 10–28 cm. longa, semper pendula. Flores quam in *D. latifolio* minores et minus densi, rubro-purpurei vel nigro-purpurei. Capsula 2 mm. in diam. Floret tempore verno.

A shrub or small tree allied to *D. latifolium* A. Cunn., but smaller. The branches are not whorled as in that species, and are much more slender. At the extremities, where the leaves occur, they are only ⅛–¼ in. in diameter. Leaves 4–12 in. long, ½–1 in. wide at broadest part, tapering to an acute point. Panicles 4–12 in. long, always drooping. Rhachis and branches yellowish-green in colour, as also sepals. Petals purplish-red or almost black; anthers white tinged with pink.

D. latifolium A. Cunn. var. *Matthewsii* Carse, *Trans. N.Z. Inst.* vol. 43, p. 238, 1911.

Hab. North Island: Dry ridges in forests from Mongonui County to Great Barrier Island and Waitakerei Ranges. September–October.

This plant bears a general resemblance to *D. latifolium*, but the smaller size in all its parts, the pendulous panicle, the difference in colour of its flowers, and the differing flowering-period (September instead of January) distinguish it clearly from that species.

In the preparation of this paper I am greatly indebted, for specimens, information, and assistance, to Dr. Carl Christensen, of Copenhagen; Dr. Petrie, of Auckland; Mr. E. Cheel, of Sydney; and to Messrs. H. B. Matthews, H. B. Dobbie, J. W. Brame, and J. Bishop; to all of whom I gladly tender my thanks for their valuable assistance.

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Dactylanthus Taylori.

Order Balanophoreae; Tribe Synomorieae.

By H. HILL.

[*Read before the Hawke's Bay Philosophical Society, 17th July, 1924; received by 31st December, 1924; issued separately, 6th March, 1926.*]

Plates 14–17.

THE root-parasite *Dactylanthus Taylori*, although known in a slight way since the year 1855 (1), has hardly received that attention from botanists which it deserves. The plant is fairly widely distributed over the North Island, to the north of latitude 40° S., ranging in bush country from near the sea-coast to inland, where it is found at an elevation of over 3,500 ft. The paucity of references connected with the life-history of the *Dactylanthus* in this country must be set down to difficulties in the way of a systematic study of this plant, as until quite lately the date of flowering was not known, and few botanists have the opportunity of seeing the growths *in situ*.

The illustrations given in (3), pl. 30, figs. 1 and 2, show attachments of tiny *Dactylanthus* rhizomes to the host, also the form of the host attachment in the case of well-grown host attachments on separation from a rhizome. So also pl. 31, fig. 1, illustrates pistillate spadices as they appear when growing on a bank in the gloom of the bush, and fig. 2 shows rhizomes with pistillate flowers as found attached to a host; pl. 32 further shows the spadices of a staminate flower surrounded by a perianth made up of sepals and petals in different whorls.

In Cheeseman (5), vol. 2, pl. 178, there is a rhizome with pistillate spadices only, attached to a host: fig. 1 illustrates a single staminate spadix, and fig. 10 gives a spadix showing both male and female flowers. There is no capitulum at the end of a scaly stem terminated by a perianth containing from 18 to 28 spadices, each spadix crowded with anthers, as illustrated in the margin, and as shown in pl. 32 of my paper (3).

As illustrated by *Dactylanthus*, by *Cordyceps*, by *Bagnisia*, and by another undescribed specimen of a parasite in my possession, the study of parasitism presents many attractive features that offer suggestions for inquiry in several directions in relation to animal and vegetable life. These parasites have allured me to Taupo and the inland bush country adjacent to Opepe on many occasions, owing to the fact that the time of their flowering was unknown. In the case of *Dactylanthus* only isolated specimens of staminate inflorescences have been seen, and much remains to be learnt of the other parasites named.

Since the issue of Cheeseman's *Illustrations of New Zealand Flora* (1914) up to March of this year it had not been possible for me to go to Taupo

except in early spring, midsummer, and midwinter. Each time Taupo was visited, a visit was also made to Opepe, in the hope of finding something new and rare in connection with parasitism. Pistillate spadices of *Dactylanthus* with fruit were usually obtainable, but never the staminate spadices, although the evidence was plain enough that the staminate flowers had bloomed.

Having decided to spend three months at Taupo, commencing in late December, 1923, it became possible to visit Opepe and the surrounding bush country where *Dactylanthus* and other rare plants are to be found. January and February, however, were unusually dry, and there was not a trace of fungoid growth or of active parasitic life. Towards the close of February, however, the weather broke, and soaking rain continued off and on during March until the date of leaving for Napier, on the 23rd. Although the weather was unfavourable, it was decided to visit Opepe on the 21st March with my native companion, Tamati te Kurapae, chief of the Ngatituwharetoa, who knows the bush country well. We arrived at our destination, eleven miles from Taupo, at 8.30 a.m.

Although hundreds of spadices of *Dactylanthus* have been examined by me from time to time, I have not seen a spadix with staminate and pistillate flowers as shown in pl. 178, fig. 10, of Cheeseman (5). This must have been sent to Cheeseman by Mr. Frank Hutchinson, jun., from the Puketitiri Bush, although rhizomes and inflorescences were sent by me to Mr. Cheeseman on many occasions.

The forenoon was spent in the bush seeking for *Bagnisia* and *Cordyceps*, but our quest for the former was fruitless, though *Cordyceps* were abundant.

Rain drove us from the bush in the early afternoon, and we sought the shelter of a camp of native rabbiters, where we obtained information about *Cordyceps* and also obtained a number of live specimens, which the Maoris call the *makaron*. The rain having ceased, we started for the gully where in former years the late Mr. A. Hamilton, of the Dominion Museum, and I had spent many delightful hours in the collection of botanical specimens, &c., and where also the late Mr. Cheeseman, F.L.S., of the Auckland Museum, had accompanied me in our search for *Bagnisia* and *Dactylanthus*. On approaching the glen I confess that my thoughts were not unmixed with sadness, for only a few weeks earlier Dr. Donald Petrie, M.A., F.L.S., an ardent botanical friend had visited me at Taupo but he was not well enough to go to Opepe.

When the Maori in whose whare we had taken shelter from the rain learnt that we were seeking for *waewae-te-atua*, by which name *Dactylanthus* is known to them, they asked to accompany us, for, although they had heard of the plant from others, they had not seen it growing. They knew the *pua-te-reinga*, which Taylor says was the native name of the *Dactylanthus*, but which the Taupo natives apply to *Bagnisia Hillii*, family Burmanniaceae: see (5), vol. 2, p. 198.

The country extending from the plateau near Opepe, 2,300 ft. above sea-level, gradually descends in the direction of Lake Taupo in a series of deep canal-like valleys for 1,000 ft. The valleys run lakeward like the spokes of a wheel from the circumference towards the centre, and each valley in its upper part represents a glen, sometimes wider and sometimes deeper than others, but all are waterless. On the banks grow many kinds of shrubs, such as *Aralia*, *Pittosporum*, *Weinmannia*, *Aristotelia*, *Carpodetus*, &c., among ferns and lycopods, and in summer most of them are truly fairy dells. On entering the glen there was a strong perfume noticeable,

which was at first set down to the moistness of the air; but it grew stronger as we moved down the valley towards the banks from which specimens of *Dactylanthus* had hitherto been collected. Although the place was so familiar to me, I had never had the slightest suspicion that the valley-floor was a veritable garden-meadow of *Dactylanthus*. Opening out, along the dry floor of the valley for a chain or more, appeared hundred of flowers in clumps. Some were in bud, some half-opened, some in full bloom, measuring 5 in. across, the whole forming a picture that was quite new to us all. As shown (Plates 14, 15, and 16, fig. 1), the flowers are all staminate, and are raised from 1 in. to 3 in. above the surface. They formed a picture never before seen by us, and expressions of pleasure and of wonder were frequent. I was reminded of the bed of *Bagnisia* plants found less than half a mile away; but the *Dactylanthus* flowers were far more numerous, and much larger, and covered a considerable area. The perfume was overpowering, and reminded me of my first find of *Dactylanthus*, more than twenty-five years ago, at Matarau, near East Cape. Near-by small rhizomes attached to small host-roots were found. These had pistillate flower-heads, which are much shorter than those attached to the rhizomes carrying staminate flower-heads, but are not buried in the ground as is the case with the staminate-bearing rhizomes. All the rhizomes with staminate flowers are buried some inches in the earth, and are much larger and different in shape from the rhizomes producing pistillate flowers. A number of clumps of the flowers with rhizomes and host attachments were carefully dug up and packed for removal as specimens, and the following is a description of the various parts:—

HOST ROOTS.

Roots of *Pittosporum* and *Aralia* are the ones most frequently attacked. Those with staminate rhizomes, which are buried some inches below the surface near the place of attachment, are sometimes 1 in. or more in thickness. The rhizome when fresh can easily be separated from the host by means of boiling in water. The expanded surface of the host very closely resembles the petals of a pansy (Plate 16, fig. 1), and suggests a powerful suction as between host and rhizome. There is no trace that the host suffers from the attack of the parasite, but from specimens collected tiny rhizomes attach themselves to a root not at the end but on the side. When fully grown, however, the rhizome always represents the terminal end of the root. Plate 17, fig. 1, shows the appearance of a host attachment after separation from the rhizome.

RHIZOMES.

The rhizomes containing pistillate flower-heads are much smaller and flatter, and possess warty-looking shoots over the whole surface. The flower-stem is much shorter than in the case of staminate flower-heads. The staminate rhizomes are buried in the ground and grow to a much larger size than the disc-like rhizomes bearing pistillate flowers. When dug up most of the specimens of rhizomes containing staminate flowers had shoots growing in bundles not unlike bundles of young asparagus. These do not appear to reach maturity, but die away following the decay of the spadices forming the staminate inflorescences. From the inside of the rhizome there radiates from the centre, where it is attached to the host, a series of smooth ridges corresponding to the depressions in the petal-like surface of the host. These extend to the cortical layer on the outside, where tiny shoots are formed. Under the microscope these shoots are of two kinds—

one containing tiny leaves, the other a pollen-like material having the appearance of resin. When fresh, some of the rhizomes can be cut with a knife and are not unlike pith. The colour is purple, and the taste is neutral. The rhizome hardens by exposure, and when soaked in water gives it a deep-golden colour.

Flowers.

A. *Staminate.*—A flower-shoot from a staminate rhizome varies in length from 4 in. to 8 in. Scales appear sparsely along its whole length, increasing in number and form up to the perianth. As shown in Plate 16, fig. 1, the perianth consists of sepals and petals, the former being wider and shorter, the latter linear-oblong, the upper tip showing enlarged corners like a cat's ears. The petals vary in colour from a light to a dull purple, and the sepals are streaked here and there with a faint purple colour. The number of leaves in the perianth (see Plate 16, fig. 2) varies from 18 to 28, as seen. The perianth encloses 20 or more spadices. Each spadix is not unlike a canoe-paddle or beaver's tail, the upper part of which is crowded with anthers as shown in the illustration. The anthers are very numerous, and are attached to the spadix in a small curve from left to right. The anthers split lengthwise, and are full of pollen, which resembles under the microscope the resin-like material in the warty shoots of a rhizome. At the place of attachment of spadix and petal there is a tiny claw (Plate 16, fig. 1, *c*). In the centre of the spadices is a small abortive pistil.

B. *Pistillate.*—A pistillate inflorescence consists of a scaly stem shorter and less robust than the staminate one. It is terminated by a perianth enclosing 30 or more spadices (Plate 16, fig. 3, *c*). Each spadix consists of a number of pistillate flowers along its whole length. The style and stigma persist up to the time when the seed is ripe, as do also two tiny scale-like attachments to the ovary. The fruit is a small nut, hard and dry. On the removal of the skin-covering the white portion has the appearance of boiled rice, or coconut. Under the microscope no embryo could be found. In all the specimens examined no single spadix was found containing both male and female flowers as shown in Cheeseman's illustration (5). The flowers are dioecious, sometimes monoclinous.

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Dactylanthus Taylori: Rhizome and pistillate flowers.

Face p. 90.]

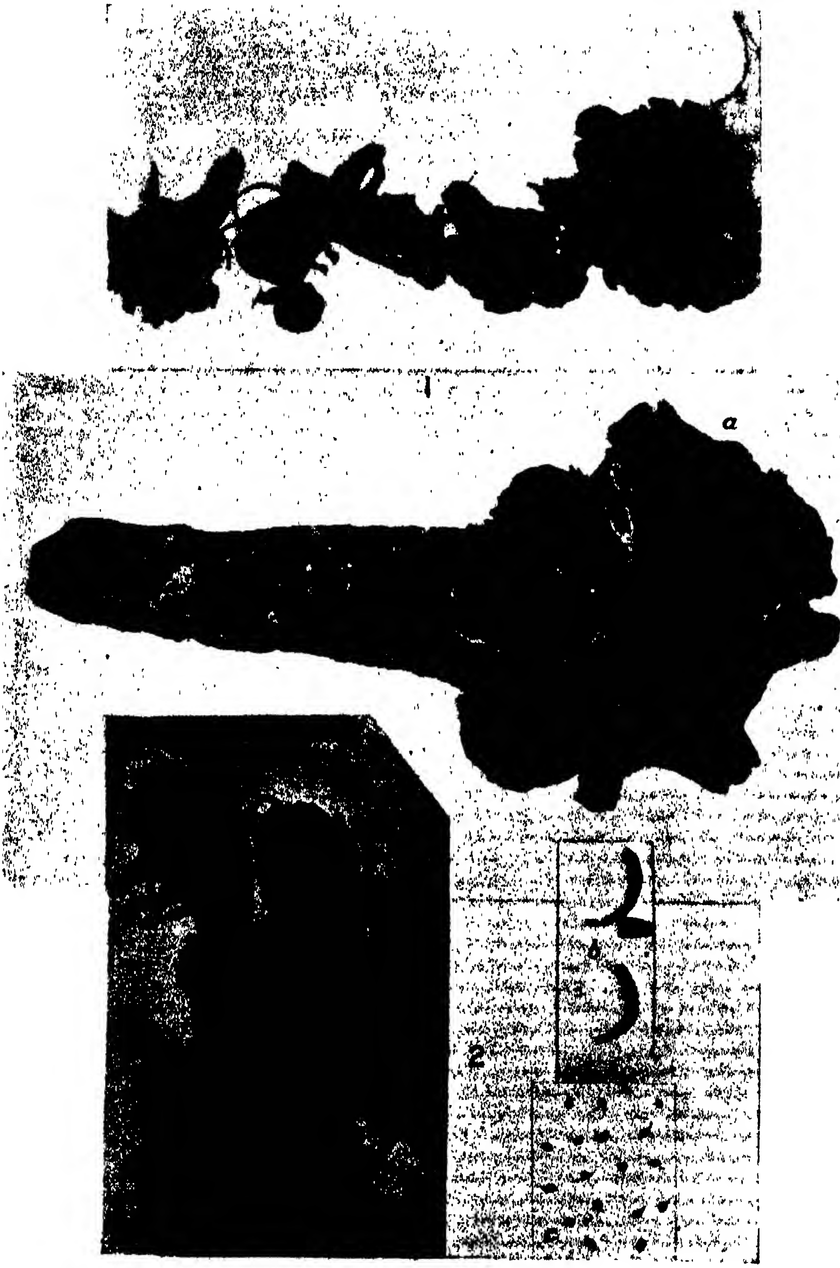

FIG. 1.—Host attachments of rhizomes. 1a, a single attachment.
FIG. 2.—a, pistillate flowers, showing attachments of flowering-stem to rhizome; b, pistillate spadix; c, seeds.

Geology of the Rakaia Gorge District.

By P. T. Cox.

[*Read before the Canterbury Philosophical Society, 4th June, 1924; received by Editor, 30th July, 1924; issued separately, 6th March, 1926.*]

Plate 18.

CONTENTS.

1. INTRODUCTION.

The district dealt with in this paper is that immediately surrounding the gorge through which the Rakaia River passes before issuing from the mountainous region of the Southern Alps on to the Canterbury Plains—or that part of the valley of the Rakaia River which lies between the Mount Hutt Range, Fighting Hill, and Round Top, the southernmost peak of the Rockwood Range. The general structure of the area is that of an aggraded, glaciated valley, into the floor of which the river has re-entrenched itself. In the central part of the district the river in thus lowering its bed has encountered a barrier of resistant Tertiary and pre-Tertiary rocks, and has cut through it a winding gorge.

References to the Rakaia Gorge district are found in many of the reports of the early geologists of this country. The most comprehensive accounts of the stratigraphy and general geology of the area are those of Haast (1871), in a report on the Malvern Hills, and Cox (1884), in a report on the Selwyn and Ashburton Counties. Since the work of Cox, however, there has been no further investigation. An attempt is therefore made in this paper both to give a more detailed account of the district than has hitherto been published, and to examine some of the problems which the outcrops present in the light of the newer conceptions of the geological history of New Zealand which have evolved during the last forty years.

Thanks are due to Professor Speight for assistance both in the field and in preparation of this paper; to Mr. P. G. Morgan for his kindness in obtaining for me the rock analyses included below; and to Mr. S. Sylvester and Mr. T. A. Phillips for facilities while engaged in the field-work.

2. PHYSIOGRAPHICAL DESCRIPTION.

The map (fig. 2) indicates the arrangement of the drainage of the district. The river-bed is flanked on both sides by extensive series of

terraces. Above and below the gorge these terraces are cut out of the Pleistocene deposits, and may be of considerable longitudinal extent. About the gorge they may be cut from older rock or may be of composite structure; these terraces are in general of much more restricted extent and of more complex arrangement than those above or below the gorge.

The valley where it issues on to the plains is broadly U-shaped in cross-section. To the south the slopes of Mount Hutt (6,810 ft.) show the typical smoothed surfaces with truncated spurs of a glaciated region.

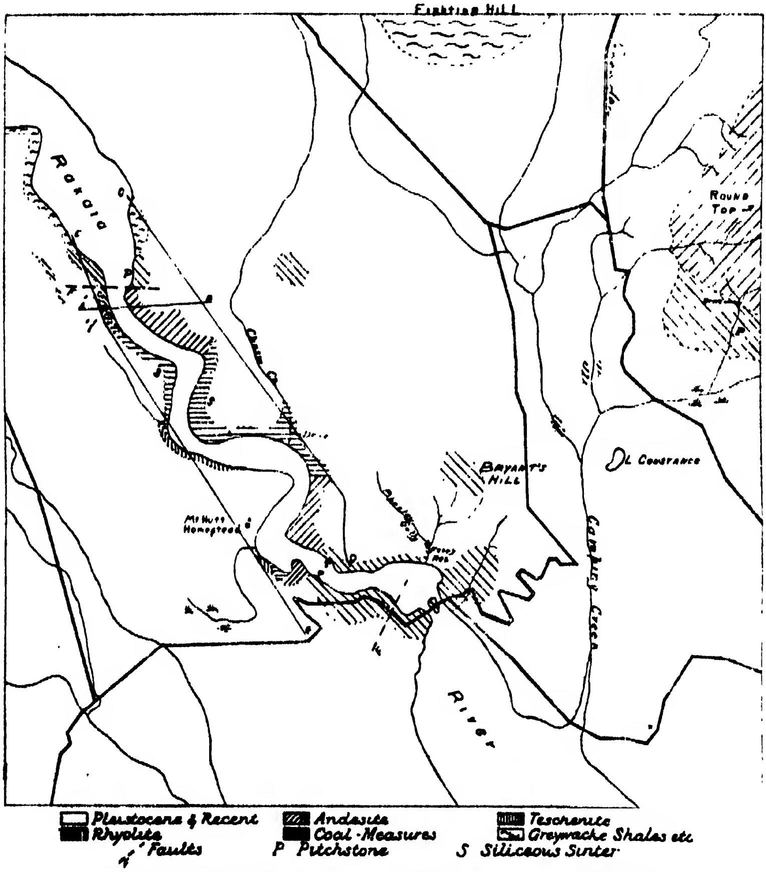

Fig. 1.—Geological sketch-map of the Rakaia Gorge district.

On the other side of the valley Round Top (2,917 ft.) is also smoothed and rounded, and Fighting Hill (2,393 ft.), lying to the north of the district, forms a typical *roche moutonnée*. Smaller *roches moutonnées* in this district are Bryant's Hill, to the north of the lower end of the gorge, and a low hill composed of rhyolite lying about a mile to the north-west of Bryant's Hill.

The topmost terrace, which forms the main valley-floor, is throughout this district covered with irregular masses of morainic material. In

places these moraines, which are composed of fluvio-glacial conglomerate with occasional large angular erratics of greywacke, are not more than a few feet in thickness; while elsewhere, as against the south-eastern slopes of Fighting Hill, they give rise to undulating country which indicates a thickness of 50 ft. or more. A prominent effect of these morainic accumulations is the formation of swamps and lakelets, such as Lake Constance, where erosion has failed to establish a complete drainage. The farthest extent of the moraines to the south-east is shown by an arc of deposits

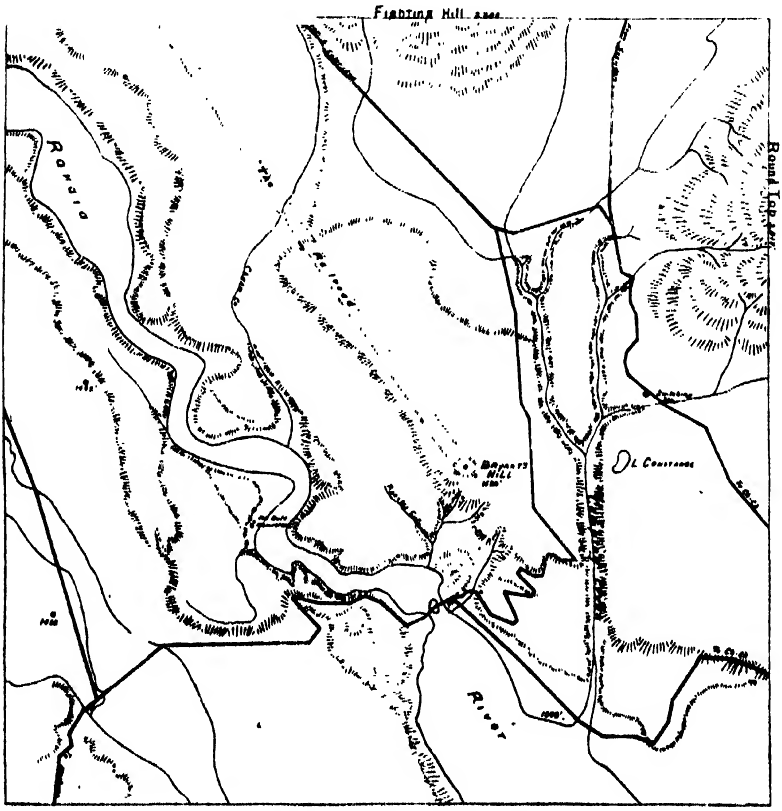

Fig. 2.—Topographical sketch-map of the Rakaia Gorge district.

of somewhat greater thickness than those immediately behind it, which stretches from about the Glenroy Saddle, through Woolshed Hill, to the south-eastern end of the Mount Hutt Range.

A prominent physiographical feature of this district is what is known locally as "The Railroad," which consists of two roughly parallel ridges running from Bryant's Hill in a north-westerly direction to the river-bed west of Fighting Hill. Since a full description and discussion of the origin of this feature has been given by Speight and Dobson (1923), further mention of it will be omitted from this paper.

3. STRATIGRAPHY.

The following table shows the succession of rocks observed in the **Rakaia Gorge district, with their approximate age correlations :—**

Sedimentary.	Igneous.	Correlations.	
		European.	New Zealand.
7. River silts, gravels, loess, &c.	..	Recent ..	Recent.
6. Conglomerates, silts, boulder-clays	..	Pleistocene ..	Notopleistocene.
5. ..	Teschenite and allied rocks	Tertiary ..	Notocene.
4. Coal-measures	..	Upper Senonian	Piripauan.
3. ..	Andesites ..	Cretaceous ..	Pre-Notocene and post-Hokonuian.
2. ..	Rhyolites and pitchstones		
1. Greywacke, shales, &c. ..	..	Permian or Tri-	Maitai or Hoko-

(a.) Permian or Triassic Sediments.

The oldest rocks exposed in the Rakaia Gorge district consist of intensely folded and faulted beds of greywacke, indurated grits, and dark-coloured finely-laminated slaty shales. They outcrop on both banks of the river at the upper end of the gorge. On the left bank they are overlain by the lower members of the Pleistocene deposits (Plate 18, fig. 1), and meet the rhyolite in an almost vertical junction—possibly due to faulting. On the right bank they are overlain by both rhyolites and Pleistocene deposits with marked unconformity. The rocks near this junction show intense weathering, which has resulted in the formation of masses of limonite irregularly distributed within a zone of about 10 ft. thickness. Fighting Hill and the Mount Hutt Range are also composed of these rocks.

The average strike of these beds throughout the eastern part of the alpine area of Canterbury appears to be in a north-easterly direction. In the small outcrops of the Rakaia Gorge inlier, however, folding has been intense, and small overthrust faults further obscure any general orientation of the strata. The dip is always at a steep angle, and the following represents a series of observations of the strike taken at intervals of about 20 ft. along the left bank of the river: E. 18° S.; E. 61° S.; E.; E. 10° S.; N. 20° E.

The only organic remains found in these rocks in the Rakaia Gorge are some indistinct annelid tubes similar to *Torlessia McKayi* Bather. They consist of straight or slightly curved and usually flattened tubes; jointing of the body-segments is visible with a pocket-lens, each segment being about 2 mm. long. The width of the tubes varies from 2 mm. to 4 mm. These occur in a grey coarsely-laminated shale in the outcrop on the left bank, as noted by Haast in a geological map of the Malvern Hills, dated 1871, and now in the Canterbury Museum, Christchurch.

With the criteria at present available it seems probable that these rocks should be referred to the restricted Maitai series—*i.e.*, should be approximately correlated with the Maitai rocks of Nelson, which Trechmann (1917) has shown to be of Permo-Carboniferous or Permian age. Jaworski's (1915) opinion, however, should be noted—that *Torlessia McKayi* should be referred to the genus *Terebellina* and indicate Triassic age.

(*b.*) Cretaceous Igneous Rocks.

Following upon the orogenic movements of early Cretaceous times, and preceding the deposition of the coal-measures in this district, there was a period of volcanic activity which gave rise to flows of rhyolite, pitchstone, and andesite, and some andesitic fragmental deposits. The intrusion of a dyke of andesitic character into the older sedimentaries probably accompanied these eruptions.

Distribution.

At the upper end of the gorge rhyolites occur on both banks of the river, lying with marked unconformity upon the denuded surface of the above-described shales and greywacke. On the left bank they are overlain by andesite-flows and andesitic breccias; on the right bank by the lower beds of the coal-measures. The relation of the andesites on the left bank to the coal-measures and rhyolites on the right bank is somewhat obscure; this is probably due to an abrupt thinning-out of the former, such as is illustrated in fig. 3.

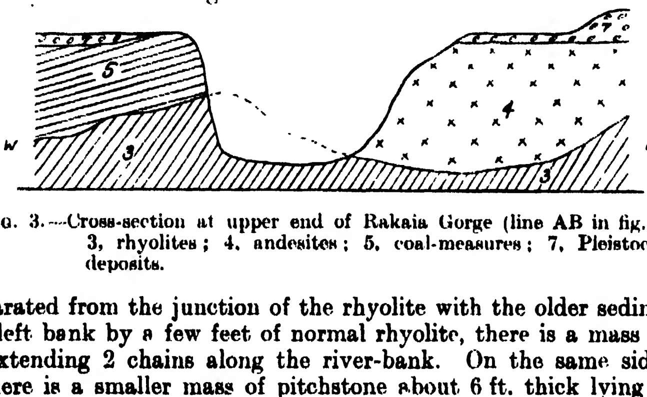

Fig. 3.—Cross-section at upper end of Rakaia Gorge (line AB in fig. 1). 3, rhyolites; 4, andesites; 5, coal-measures; 7, Pleistocene deposits.

Separated from the junction of the rhyolite with the older sedimentaries on the left bank by a few feet of normal rhyolite, there is a mass of pitchstone extending 2 chains along the river-bank. On the same side of the river there is a smaller mass of pitchstone about 6 ft. thick lying between the rhyolite and the andesite.

On the right bank no outcrop of pitchstone was found, though fragments of that rock occur amongst the talus derived from the slope on which the rhyolite meets the Maitai rocks; this probably indicates an extension of the pitchstone mass which lies near to that junction on the opposite bank.

The andesites overlying the rhyolites on the left bank are overlain farther down-stream by the coal-measures.

At the lower end of the gorge rhyolites occur on both banks, and are penetrated by pitchstones near their junction with the andesites. Lying between the pitchstone and the andesite there is a narrow layer of much-weathered rhyolite. The base of the rhyolite is hidden by the Pleistocene gravel deposits, but on both sides of the river there are clear sections showing it to be overlain by andesite-flows with interbedded andesitic breccias. The andesites, in turn, on both sides of the river are overlain by coal-measures.

An intrusion which was doubtless associated with the eruption of the andesites occurs at the upper end of the gorge on the left bank of the river, in the form of a dyke from 1 ft. to 1 ft. 6 in. in width, which penetrates the Maitai rocks. It is clearly shown in a section exposed about 7 chains up-stream from the junction of the older rocks with the rhyolites, and extends up the cliff with very uniform thickness, though with somewhat

irregular walls. The beds on either side do not show any displacement, and there is little sign of contact metamorphism.

Besides these outcrops exposed in the gorge itself, there are numerous smaller occurrences of the Cretaceous volcanic rocks in the immediate neighbourhood. In Camping Gully rhyolite has been exposed in several places below the Pleistocene deposits. Bryant's Hill, and a lower ice-worn hill lying about a mile to the north-west of it, are also composed of rhyolite. Another outcrop of this rock occurs on the terrace slope leading up to the main level of the valley-floor about 20 chains to the west of the upper end of the gorge.

In Round Top, of the neighbouring Rockwood Range, a mass of andesites and associated breccias form the upper and north-western part of the hill. These rocks apparently form a capping with a north-westerly dip of about 15°, and overlie the rhyolites of which the south-eastern slopes are composed. Here, in the gully marked P on the map (fig. 1), pitchstones also occur with the rhyolites.

Petrology.

Rhyolite.—A hard, compact rock, usually jointed into massive rectangular blocks. Through the action of weathering agents the rock generally presents a surface which is stained to a light-brown colour. When fresh it is either white or may vary in colour from green to grey or black. Megascopic crystals of quartz and garnet (almandine) are locally abundant.

Microscopic examination of specimens of this rock taken from various parts of the gorge showed that, while the texture of the groundmass varied considerably, both the mineral content and the structure of the rock was very uniform throughout, the chief mineralogical difference between the various specimens being the presence or absence of garnet. Moreover, apart from that shown in a single flow as described below, there seems to be no progressive change throughout the mass of the rock either in degree of crystallinity of the groundmass or in abundance of garnet. Almost holocrystalline flows are irregularly interstratified with flows whose groundmass may be almost completely glassy. Types rich in garnet also appear apparently irregularly arranged amongst types poor or lacking in these phenocrysts.

The minerals present as phenocrysts are quartz, orthoclase, plagioclase (andesine to oligoclase with occasional albite), garnet, and biotite. Minerals of the groundmass are quartz, feldspar, apatite, magnetite, and rarely zircon. The groundmass varies in texture in different slides, and in different parts of the same slide, from a dark-brown glass to a microfelsitic (Iddings, 1909) matrix. In a few slides indistinct micrographic intergrowths of quartz and feldspar are apparent in the more crystalline parts of the groundmass, together with patches showing microspherulitic structure. In general, however, spherulitic intergrowths are absent. Flow-structure is nearly always present to some extent, and may be very prominent. A feature of nearly all the rhyolites examined was the development of "flow-breccia" structure (Iddings, 1909, p. 331).

Pitchstone.—A brittle, easily-weathered rock, showing either (as in the outcrop at the upper end of the gorge) very perfect rectangular jointing, or (as at the lower end of the gorge) massive outcrops with little jointing. The rock is pitch-black in colour, with the characteristic vitreous lustre and conchoidal fracture of volcanic glasses. Phenocrysts of clear or slightly discoloured quartz are visible, and garnets are abundant in all of the outcrops in this district.

Under the microscope the pitchstones are markedly uniform in character and closely resemble the more glassy types of rhyolite; the occasional

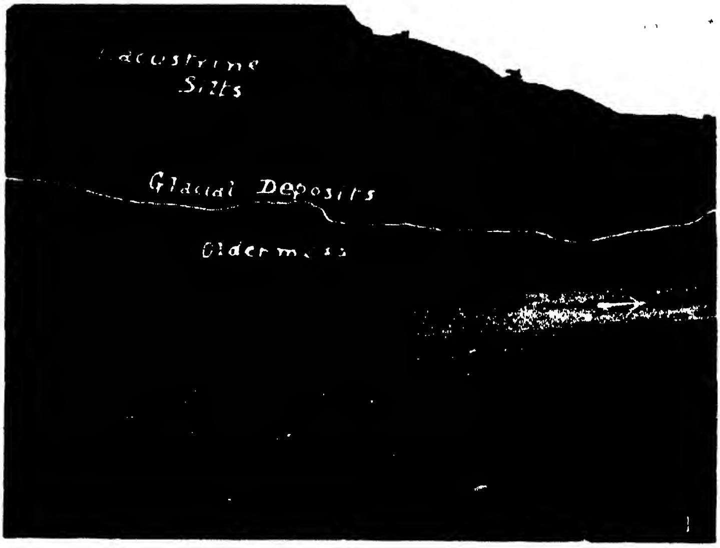

FIG. 1.—Pleistocene deposits overlying Maitai beds at upper end of Rakaia Gorge (left bank).

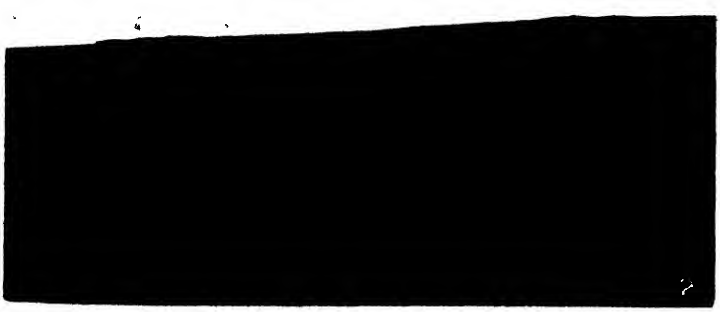

FIG. 2.—Terraces at lower end of Rakaia Gorge (right bank).

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presence of small phenocrysts of hypersthene is the only difference in mineral content, and, except that no microspherulitic intergrowths were observed in the pitchstones, their micro-structure is similar. Perlitic structure, especially in the rock of the outcrops at the lower end of the gorge, is perhaps more marked than in the glassy rhyolites.

Andesite.—The rock of which the flows are composed is a hard dark-grey or black rock, which, however, is very susceptible to the action of weathering agents. Fresh specimens of the rock are difficult to obtain except where erosion has been so rapid that the products of decomposition have not been able to remain in place. In the field the rock generally appears as a reddish or greenish mass, presenting a somewhat incoherent and crumbling surface. The only crystals visible megascopically are of feldspar, and these occur as numerous, evenly-distributed, rectangular prisms. The presence of these phenocrysts is very characteristic of the rock, and they remain visible to the naked eye or under a pocket-lens even in most weathered specimens. A very general feature of this rock is the abundance of secondary silica present as quartz of different varieties—chalcedony, amethyst, agate, and opal. These minerals, together with chloritic decomposition-products derived from the ferromagnesian minerals of the rock, are found filling veins, druses, steam-vesicles, and other cavities throughout the whole mass. In places the rock becomes scoriaceous, and the vesicles are filled with bright-green amygdaloids composed chiefly of chlorite. The presence of these minerals has led to the popular supposition that copper-ores and gold may be found in these rocks, but prospecting has failed to detect any minerals of economic value in payable quantities. The amethysts, which have attracted some attention, are of a pale colour, usually occurring in druses as clusters of small hexagonal prisms terminated by pyramids. Specimens have been collected from the face opposite the Mount Hutt homestead up to 4 in. in length, but these are exceptionally large for this locality

Calcite is also common as a vein-mineral in the andesites. On the southern slopes of Round Top there are veins varying in size up to 2 ft. which have been partially filled with calcite, quartz being subsequently deposited as a coating on the calcite, and giving rise to negative pseudomorphs.

The breccias associated with the andesite-flows are typical volcanic breccias consisting of angular fragments of the andesite rock varying in diameter up to 2 in. or 3 in. with occasional larger blocks cemented together in a matrix of finer material. There is no apparent regularity in arrangement of the flows and fragmental deposits, but the former are in far greater abundance. The breccias occur merely as occasional strata, never more than a few feet in thickness, interbedded between the flows. The secondary minerals associated with the andesite-flows are also abundant in the breccias.

The microscopic character of the andesites is very uniform in all specimens collected from this district. The chief variations observed were in the proportion of ferromagnesian minerals present and in the texture of the groundmass. Plagioclase (acid-labradorite to andesine), hypersthene, and augite occur as phenocrysts in a groundmass which is typically composed of minute feldspar laths, some pyroxene in granular masses, magnetite, and a brown glass. The texture of this matrix varies in different slides: in some there is little glass and the feldspar laths attain a larger size, when they may be recognized as andesine or labradorite; in other slides the glassy material predominates, and the feldspars appear as scattered microlites. The amount of pyroxene present in the groundmass also varies, being in some slides apparently absent. In general the structure is hyalopilitic as defined by Rosenbusch, the "felted" character being prominent in the more crystalline

varieties. Throughout the rock there is much secondary quartz and opal, filling small veins and cavities. Small round vesicles frequently show a border of radiating, fibrous, chalcedonic quartz, with the centre filled in with opal.

The rock forming a dyke in the greywacke at the upper end of the gorge is much weathered, and presents a brown sandstone-like appearance. Plagioclase (acid-labradorite), augite, ilmenite, apatite, and a large amount of secondary quartz and calcite are recognizable under the microscope. The texture is of a fine, even grain, the bulk of the rock being composed of feldspar laths with occasional patches of glassy residuum. It would seem more probable that the intrusion of this dyke was associated with the Cretaceous volcanic activity than with the Tertiary basic intrusions, solely on account of the andesitic character of the rock.

The following are the results of analyses made in the Dominion Laboratory of specimens of each of the effusive rocks of this group, with their classification according to the C.I.P.W. system :—

			(1.)	(2.)	(3.)
Silica	SiO_2	..	75·68	69·54	58·57
Alumina	Al_2O_3	..	12·45	13·18	17·03
Ferric oxide	Fe_2O_3	..	0·44	1·04	4·85
Ferrous oxide	FeO	..	0·40	0·92	1·33
Magnesia	MgO	..	0·07	0·31	1·17
Lime	CaO	..	0·66	1·06	5·45
Potash	K_2O	..	6·41	2·25	2·70
Soda	Na_2O	..	2·14	4·16	3·20
Water lost above 105°	C.	..	0·66	4·98	1·23
Water lost below 105°	C.	..	0·58	2·16	2·60
Carbon dioxide	CO_2	..	0·11	Trace	0·09
Titanium dioxide	TiO_2	..	0·19	0·21	1·38
Zirconium dioxide	ZrO_2	..	0·01	0·01	0·01
Phosphorus pentoxide	P_2O_5	..	0·20	0·11	0·32
Sulphur		..	None	None	None.
Chromium trioxide	Cr_2O_3	..	None	None	None.
Nickel oxide	NiO	..	Trace	Trace	0·02
Manganous oxide	MnO	..	0·01	0·02	0·11
Strontia	SrO	..	None	None	None.
Baryta	BaO	..	0·06	0·10	0·05
Lithia	Li_2O	..	Trace	Trace	Trace.
			100·07	100·05	100·11

(1.) Rhyolite: the island, lower end of Rakaia Gorge.
(2.) Pitchstone: lower end of Rakaia Gorge, north side.
(3.) Andesite: lower end of Rakaia Gorge, south side.

In (1) and (2) the analyst reports that the carbon dioxide is not present as calcite, as it is liberated only on heating to about 100° C with dilute hydrochloric acid.

	(1.)	(2.)	(3.)
Quartz ..	37·86	34·14	17·16
Orthoclase	37·81	13·34	16·12
Albite ..	17·82	35·11	27·25
Anorthite	1·95	4·45	23·91
Corundum	1·43	2·24	..
Diopside	..	..	0·46
Hypersthene	0·20	1·33	2·80
Magnetite	0·70	1·39	..
Ilmenite	0·46	0·46	2·74
Haematite	..	..	4·96
Apatite ..	0·34	0·34	0·67
Calcite ..	0·20	..	0·20

(1.)	I	3 (4)	1″	2″	(Magdeburgose).
(2.)	I	3 (4)	(1) 2	4	(Alsbachose).
(3.)	I (II)	4	3	(3) 4	(Yellowstonose).

The chief points of interest regarding the composition of these rocks arise out of a comparison of the rhyolite and pitchstone. As is suggested below, the pitchstone may represent merely certain of the acidic flows of these eruptions, which, either owing to rapid cooling or other causes by which free molecular movement was hindered, have consolidated in a more vitreous form. If this is the case the rocks should show similar chemical compositions. The difference in relative proportion of the alkalis is, however, marked: the potassic nature of the rhyolite shows itself mineralogically in the abundance of orthoclase relative to the soda-bearing feldspars, while in the pitchstone the reverse occurs. The chemical similarity of the two rocks, however, seems sufficient to admit of their being successive flows of the same eruption, a conclusion to which the field evidence points.

Comparison of these analyses with those given by Speight (1922, p. 79) of Banks Peninsula rhyolites and pitchstones shows a general similarity.

Owing to the abundance of secondary silica contained in the andesite, the C.I.P.W. quantitative classification, which the authors definitely limit to fresh specimens, does not illustrate the character of the rock. Classified as "yellowstonose," it is grouped with dacites and rocks corresponding in composition with quartz-diorites, whereas its mic.oscopic character clearly shows that it belongs to a more basic group.

The Origin of the Pitchstones.—Haast (1871 and 1879) considered the pitchstone to be merely a facies of the rhyolite—the first flows to be erupted on to a cold land-surface. Cox (1884, p. 40), however, considered the pitchstone to be dykes belonging to the same system as the dolerite and basalt intrusions found penetrating the coal-measures and older rocks. The following evidence seems to confirm Haast's view that in this and neighbouring districts they are merely glassy facies of the rhyolite:—

1. No instances have been reported of the pitchstones associated with the volcanic rocks here considered penetrating any rocks other than the rhyolites.

2. In every outcrop observed the directions of the pitchstone masses conform to those of the apparent flows of the rhyolite. The presence of jointing frequently makes it difficult to determine the orientation of the flows of the rhyolite, but where determination is possible the pitchstone is found to be in parallel arrangement. This is especially true of the occurrence at the lower end of the Rakaia Gorge, where the direction the rhyolite-flows is clear.

3. There are certain undoubted rhyolite-flows which may be considered as intermediate in character between the normal pitchstone and rhyolite types. They are black in colour, show a somewhat vitreous lustre, and microscopically appear as very glassy rhyolites. Other flows which are chiefly composed of normal rhyolite at the margin grade into a pitchstone type as shown above.

While it thus seems more likely that the pitchstones do not form dykes, yet Haast's inference that they represent those flows resting directly upon the older rocks, and therefore cooled more rapidly than the succeeding flows, requires some modification. The presence of normal rhyolite between the pitchstone and the older (Maitai) rocks shows that, whatever may have been the cause of the glassy facies, it was not due to conditions attendant only upon the first flow to be put out on to the land-surface. Furthermore, the pitchstones occurring near, but here also not next to, the junction with the andesites, may only be due to this rapid cooling of the first flow if the andesites represent the older of the two volcanic series. As shown below,

however, the weight of evidence seems to point to the andesite being of younger origin than the rhyolite. Thus while it is possible that the first flows of the rhyolitic series in places may have assumed a glassy character, yet the pitchstone facies is by no means confined to that horizon.

In the Rakaia Gorge it must be considered as accidental that each of the pitchstone outcrops occurs close to, though, as careful examination shows, not in actual contact with, the junction of the rhyolites with other rocks.

Order of Eruption of the Rhyolites and Andesites.—Haast, in treating of this and the adjacent Malvern Hills and Mount Somers districts, always considered the andesitic eruptions to have preceded the rhyolitic. Cox, who was the last to discuss at all fully the mutual relations of these two series of rocks, agrees with Haast that the andesites were the first erupted rocks, but in view of inconsistencies arising from an adoption of this theory in the Malvern Hills and Rakaia Gorge he postulates a special type of eruption for the rhyolites. These rocks he considered to have been erupted in a very viscous condition, the accumulation taking place by a process of endogenous growth, as described by Judd (1881, p. 134). Of recent years, however, there has been some doubt cast on this hypothesis, and a close examination of the Rakaia Gorge district, supplemented by more rapid observations in the Malvern Hills and Mount Somers districts, would seem to show that there is a balance of evidence in favour of the rhyolite being the first erupted rock.

Haast does not state definite reasons for considering the andesites to be older, but Cox bases his endogenous-growth theory upon the following observations :—

(1.) Micro-structure of the rhyolite indicates a viscous lava.

(2.) On the flanks of Mount Somers the andesites dip inwards towards the main rhyolite mass.

(3.) " The fact . . . that the melaphyres are lying on the liparites [in the Rakaia Gorge] at the angle of dip which they assume is in itself a proof of greater age, when we consider that beds of tufa are interstratified with the solid floes." (Cox, 1884, p. 39.)

Of these lines of evidence, (1) is of merely accessory value ; (2) and (3) may both be criticized in the light of later advances in the science of New Zealand geology. At the time of Cox's report the conception of a Pliocene period of crustal movements had not been developed. The work of McKay, Cotton, and others, however, has since shown that the present topography of New Zealand is independent of that of pre-Notocene times. Thus the fact that the andesites flanking Mount Somers dip towards the centre of that mass must be considered as possibly due to the presence of faults. The third argument is also open to criticism. The coal-measures overlie the andesites in this place with a dip of not less than 35° ; so that, taking Cox's angle of dip of the andesites (45°), and allowing that no movements have disturbed the igneous rocks relative to the coal-measures, the angle of slope at which the tuffs and breccias were laid down could not have been greater than 10°. This occurrence therefore seems insufficient as " a proof of greater age " of the andesites.

A further point which doubtless influenced both Haast and Cox in considering the relative age of these rocks is that they supposed that there were beds of rhyolitic tuffs interstratified with the coal-measures at Mount Somers and the Rakaia Gorge. As shown below, however, the coal-measures in the Rakaia Gorge are probably entirely of cataclastic origin.

With regard to the possible objection that if the andesites overlie the rhyolites the solutions which deposited the silica, calcium carbonate, &c., in them would be expected to have penetrated the underlying rhyolites, two suggestions may be made. Such solutions were probably closely connected with the magma itself, and deposition of the secondary minerals would follow closely upon the consolidation of the rock, and be to a large extent confined to it. Secondly, the rhyolite, being of a compact nature, would not easily be penetrated by these solutions. The fact that small amethysts, with some veins of chalcedony, occur in the rhyolite on the right bank at the lower end of the gorge shows that these solutions did to some extent affect this rock.

The evidence in favour of the rhyolites having preceded the andesites is—

(1.) The andesites in each outcrop of the Rakaia Gorge occur between the outcrops of rhyolite and coal-measures, and in Round Top rest upon the rhyolite. The possibility of faulting having caused an inversion of the older rocks over the younger is unlikely.

(2.) The nature of the contact of the andesites with the rhyolites at the lower end of the gorge. The rhyolite which lies between the pitchstone and the andesite is much weathered and decomposed to an easily eroded white mass.

Where the rhyolite rests upon the older Maitai rocks there is little evidence of alteration of the erupted rock. This seems to indicate that the weathered rhyolite represents an old land surface upon which the andesites were erupted.

The supposition that either the andesites or the rhyolites of the Malvern Hills and Rakaia Gorge were not contemporaneous with those of the Mount Somers district would clear away the chief difficulties involved in this problem. The rhyolites of both districts, however, in megascopic and microscopic character are almost identical, and both have similarly associated pitchstones. The andesites of both districts are also of a closely similar nature, and since both series are definitely of Cretaceous age it must be considered very improbable that the eruptions of each type were not contemporaneous in both districts.

(c.) Cretaceous Sediments.

Distribution.

The coal-measures overlying the rhyolites and andesites in the Rakaia Gorge are the only members of the Notocene group of sediments exposed in this district. They outcrop as part of a basin-shaped fold which is tilted towards the south-west, so that one-half of the basin is obscured below the Pleistocene deposits on the south side of the river. The maximum thickness exposed is about 1,000 ft. At the upper end of the gorge on the right bank they rest on a denuded surface of the rhyolite, and strike W. 30° N. with a southerly dip of 30°. On the left bank the coal-measures occur in the central part of the gorge, resting on the andesites. At the upper end of the outcrop the strike is roughly north and south, but in Chasm Creek it has swung round to N. 15° E., and the beds dip at 30° to the west. Following the outcrop down-stream, the strike continues to swing round, following the edge of the basin, until, where again the beds may be seen resting on the andesites, it has assumed a N.N.E.–S.S.W. direction, and the beds dip at an angle of 35° to the W.N.W. On the right bank, below the Mount Hutt homestead, these beds occur again resting on the

andesites with a north-east strike and dipping at 35° to the north-west. Thus the southern wing of the exposed segment of the basin is completed; further evidence of the form of the beds to the south-west is buried beneath the later deposits of gravel and silts lying between the river and the foot of the Mount Hutt Range.

In both outcrops of coal-measures on the right bank the topmost bed exposed is overlain by the teschenite rock of a sill: elsewhere the Pleistocene deposits follow unconformably.

Petrography.

The coal-measures consist for the most part of coarse conglomerates with interstratified beds of shale and sandstone and seams of brown coal. Current-bedding is a prominent feature of the deposits wherever exposed. Associated with these sediments, and more especially with the coarser conglomerates exposed on the right bank near their junction with the teschenite sill, there is a considerable quantity of fossil wood which has been preserved by partial petrifaction. Large pieces of tree-trunks and boughs often several feet in length occur associated with limonite masses, and usually containing radiating tufts of fibrous haematite at the nodes.

In two places, marked S on the map (fig. 1), there are deposits of siliceous sinter together with silicified grits and sandstones. These deposits occur at about the same level on opposite banks of the river, and probably represent a period of thermal activity following upon the above-described volcanic activity. The partial silicification of the wood-remains and the formation of haematite are doubtless largely due to the action of waters associated with the deposition of this sinter.

There is little regularity in the arrangement of the beds of different texture throughout the sequence. Conglomerates are the predominant type, and occur throughout. In general the lower beds exposed are of finer material than those of the higher parts of this inlier. The seams of coal are also distributed irregularly, the thickest seams occurring in the upper half of the sequence.

1. *The Coarse-grained Beds.*—The conglomerates consist of closely packed pebbles of rhyolite varying in diameter up to 6 in. Together with the rhyolite debris there are occasional pebbles which may possibly be composed of much-altered greywacke, but close searching failed to show the presence of any andesite pebbles. In view of the close association of the andesites with the rhyolites in the district, this feature of the deposits requires some explanation. The possibility of the andesites being of later eruption than the deposition of the coal-measures is precluded by their undoubted mutual position. That the andesite pebbles, being more easily decomposed than the rhyolite, have been completely removed by weathering agents, either during deposition or subsequently, is also unlikely. An explanation is more probably to be found in a consideration of the locality from which the waste forming these beds was derived. The well-worn and rounded condition of the rhyolite pebbles suggests that they have been transported for a considerable distance. It is possible that the rhyolites may have extended to the east of the present outcrops over a wide tract of country, from which the pebbles of the coal-measures were derived, whereas the andesites were confined to within the area of deposition. This tract of rhyolite country would now be buried beneath the gravels of the Canterbury Plains, which (Speight, 1915) doubtless occupy the position of an infilled, down-faulted block. The facts that parts of the greywacke surface (now "fossil peneplain") are found to the

west of this district with coal-measures lying directly upon them, and that rhyolite pebbles are found in the Notocene rocks of the Broken River and Big Ben outliers, supports the idea of an early Notocene land-surface to the east rather than to the west of the Rakaia Gorge district.

2. *The Fine-grained Beds.*—The finer sediments of the coal-measures consist of normal sandstones, grits, mudstones, and shales. Being doubtless derived from the same landmass that supplied the rhyolite pebbles of the conglomerates, these rocks are usually light in colour and of a siliceous character. In many cases there is much finely-divided carbonaceous matter scattered throughout.

There does not seem to be any evidence of volcanic tuffs in these coal-measures, as assumed by Haast and Cox. The section referred to by Cox (1884) as showing tuffs at the upper end of the gorge shows the normal succession with no brecciated material, volcanic bombs, or lapilli, and the sandstones and mudstones are interbedded with conglomerates of well-worn pebbles. The firmly-cemented character and light-grey or white colour of the finer-grained beds certainly give rise to a superficial resemblance to some volcanic tuffs, but the presence of finely-comminated plant-remains scattered irregularly throughout many of them disposes of this possibility. The colour, moreover, is readily understood, since these beds doubtless represent the detritus from a landmass which was largely composed of rhyolite.

3. *The Coal.*—The coal-seams vary in thickness from a few inches to about 10 ft. The thickness of any one seam may also vary considerably when traced laterally, the masses of coal being usually in the form of lenses of slight convexity. The coal itself when unaltered is a brown, hydrous coal, very similar in character to that being worked at Homebush, White Cliffs, Glenroy, Mount Somers, and elsewhere in Canterbury. On the right bank, near the junction of the coal-measures with the teschenite sill, it assumes a semi-anthracitic character, due to thermal metamorphism induced by the intrusion.

In the Rakaia Gorge the coal has been worked privately by the various owners of the land for their own consumption. On the left bank, in Chasm Creek, drives have been put in to a distance of about 100 ft. at two levels, to work a seam of 10 ft. thickness. Farther down-stream, on the same bank, a shaft was sunk near the junction of the coal-measures with the andesites, in order to pick up this seam again. Though doubtless it was passed through, it had here thinned out, and nothing of profitable thickness was found. These workings, which were carried out by Mr. George Gerard, of Snowdon, have been discontinued for the last twenty years, since all the easily-accessible coal has been removed. There is no record of the amount of coal extracted.

On the right bank of the river certain of the holders of the Mount Hutt Station have extracted small quantities of coal from the outcrops near the junction of the coal-measures with the sill described below, and near the junction with the andesite below the homestead. In these two places drives have been put into seams of from 4 ft. to 6 ft. in thickness for a distance of about 80 ft.

Age.—Since the fossil wood referred to above is the only recognizable organic material as yet found in the coal-measures of the Rakaia Gorge, the age of these beds can only be inferred by correlation with neighbouring districts. The lithological similarity and the identity of relations with the rhyolite leave no doubt, however, that the Rakaia Gorge coal-measures are the correlatives of those of the Malvern Hills, which (Trechmann, 1917; Woods, 1917; Wilckens, 1922) have been determined as Upper Senonian (Piripauan).

(*d*.) Tertiary Igneous Rocks.

Distribution.

Overlying the topmost beds of the coal-measures exposed on the right bank in the central part of the gorge is a mass of igneous rock in the form of a sill. There are two outcrops of this rock: one, forming a cliff with a maximum height of 200 ft., extending in an east-and-west direction to the north of the Mount Hutt homestead; the other a bank varying up to 10 ft. high and about 5 chains long which lies about 20 chains south of the homestead. The junction of this rock with the underlying coal-measures is clearly visible; near it the normal sediments have been altered to a hard spilosite-like rock, and in an adjacent coal-seam the normal brown coal has been changed to a semi-anthracite analogous to similar altered coals in the Acheron River and Malvern Hills. From the nature of the contact and the lithological character of the whole mass it is evident that this body of rock represents a sill intruded into the coal-measures. The upper part of the intrusion and any overlying Notocene sediments have been either removed by erosion or buried beneath the deposits of Pleistocene silts and conglomerates.

Petrology.

The texture of this rock varies markedly at different levels. At its lower margin, where it is little weathered, it appears as a dark, hard rock of fine grain. Proceeding upwards it becomes coarser in texture, until at the highest point of its exposure it appears as a coarse-grained rock much weathered to a dark-green incoherent mass. In this part of the sill there are numerous small veins, varying from ½ in. to 2 in. in thickness, and arranged roughly parallel with the floor. The rock of which these veins are composed is of lighter colour and finer grain than the enclosing country.

The following are the chief types which occur as various facies of this intrusion:—

(1.) Coarse-grained or teschenite type. Coarse even-grained rock containing plagioclase (labradorite), titan-augite, olivine, analcite, prehnite, biotite, ilmenite, and apatite. Ophitic structure was not observed.

(2.) Non-porphyritic or dolerite type. Even-grained but of much finer texture than (1). Plagioclase (acid-labradorite), titan-augite, aegirine-augite, olivine, biotite, apatite, and ilmenite present. Ophitic structure slightly developed.

(3.) Porphyritic or basalt type. Very fine grain with small phenocrysts of olivine and a slightly greenish augite. The groundmass consists of a fine-grained though holocrystalline matrix of small labradorite laths together with some granular augite and a little olivine. Ilmenite is also abundant.

(4.) Vein rock. Of typically granulitic texture and containing orthoclase, nepheline, analcite, pyroxene (both titan-augite and aegirine), barkevicite (occasional granular crystals), biotite, and ilmenite. Slides made from the margin of these veins show an abrupt transition, though with no definite line of division, into the normal country rock by decrease in the nepheline and orthoclase with increase in the mafic elements.

Of these types, (1), (2), and (3) grade insensibly into each other, and depend upon distance from the margin of the intrusion. The whole group

is a typical suite of teschenitic rocks, and bears a close resemblance to many of the Scottish analcite rocks (Tyrrell, 1923; Walker, 1923).

The vein rock, which corresponds in mineral composition to a nepheline syenite, is of interest as showing a leucocratic differentiate of the magma from which the intrusion was derived. The process of differentiation was doubtless of the type in which the veins represent the product of a fluid residuum which has been squeezed along lines of weakness in the mass and has crystallized after the consolidation of the main bulk of the rock. The rock may thus be compared with the aplites of acidic rocks; the almost panidiomorphic structure of the vein-rock of this sill is noteworthy in making this analogy. Tyrrell (1923) shows that differentiation of a teschenitic magma in a syenitic direction will result in a theralite. The vein-rock of this sill does not, however, contain plagioclase, and thus represents a still further stage in the differentiation process—a nepheline syenite.

The age of the intrusion of this sill cannot be determined within close limits. It is post-Senonian and pre-Pleistocene. Probably it was intruded contemporaneously with the numerous other similar basic intrusions of Canterbury, and may have been associated with the Kaikoura orogenic activity, which reached a maximum in Pliocene times. It is, however, involved in the same folding and faulting that was then induced in the Notocene sedimentary rocks.

(*e*.) Pleistocene Sediments.

Distribution.

Overlying the Notocene and older rocks of the Rakaia Gorge inlier there are deposits of more or less unconsolidated sediments, including fluviatile conglomerates, lacustrine silts, glacial and fluvio-glacial deposits. These sediments surround the inlier, and form the material with which the Rakaia Valley is aggraded. They extend from the base of the Mount Hutt Range to Fighting Hill and the Rockwood Range, and form a continuous sheet between these two elevations into the High Peak basin. Upon the slopes of Round Top and the adjacent members of the Rockwood Range greywacke boulders representing glacial deposits of this age occur up to a height of 1,340 ft. above the level of the water at the lower end of the Rakaia Gorge. To the south-east of this district these Pleistocene deposits extend outwards to form the Canterbury Plains. In this district these deposits attain a great thickness above and below the gorge, where the river has eroded to a depth of 700 ft. below their surface without reaching the underlying rock.

Petrography.

The chief types of sediments represented in this series are:—

(1.) Conglomerate: coarse to medium grained, the pebbles having an average diameter of 3 in. or 4 in. Greywacke is the chief rock of which the pebbles are composed, but limestone, dolerite, gabbro, and, below the gorge, rhyolite and andesite, are sparsely represented. These gravel-conglomerates form by far the greater part of the Pleistocene deposits, and of them two distinct types may be recognized: one is stained to a light-brown colour through oxidation of the iron-bearing minerals under the action of weathering; the other is of the normal grey colour of the greywacke pebbles.

(2.) Silts: fine-grained, of a yellow or white colour. Usually show "varve" banding of very fine and slightly coarser material, each band

being from $\frac{1}{4}$ in. to $\frac{1}{8}$ in. thick. Occasional pebbles of greywacke are scattered throughout the deposits of this silt, suggesting transportation by floating ice during the time of deposition.

(3.) Fluvio-glacial conglomerate: composed of angular and striated boulders together with normal rounded pebbles of fluviatile gravels. Large angular boulders varying up to 4 ft. or 5 ft. in diameter occur in these beds. Greywacke, as in the normal fluviatile conglomerates described above, is the chief rock of which the boulders and pebbles are composed. The whole is cemented together with a very fine glacial silt.

(4.) Boulder-clay: a typical glacial boulder-clay consisting of angular boulders of variable size, some of which are smoothed and scratched, embedded in a very fine-grained silt. The boulders in this case also are almost exclusively composed of greywacke.

Correlation of the various sections of these deposits exposed in and about the gorge is rendered difficult by lack of continuity of the beds. The following represents the general succession observed:-

7. Loess, sands, and other recent superficial deposits.
6. Upper fluvio-glacial conglomerate.
5. Grey fluviatile conglomerate.
4. Brown fluviatile conglomerate.
3. Lacustrine silts.
2. Lower fluvio-glacial conglomerate.
1. Boulder-clay.

The complete succession is not, however, shown in any single section. The following may be taken as representative exposures illustrating the stratigraphical relations of the several deposits:—

(1.) At the upper end of the gorge, resting upon the Maitai rocks on the left bank (Plate 18, fig. 1):—

7.	Blown sands, river-gravels, &c.	10 ft.
3.	Fine-grained lake-silts	30 ft.
2.	Silts with interstratified fluviatile conglomerates; conglomerates increasing with depth ..	30 ft.
	Fine silts with occasional boulders	10 ft.
1.	Boulder-clay	10 ft.
0.	Greywacke.	

(2.) At the lower end of the gorge, on the right bank, up-stream of the bridge. The sequence of beds, though somewhat obscured below the road by talus, appears to be as follows:—

7.	Superficial deposits	2 ft.
5.	Grey fluviatile conglomerate	30 ft.
3.	Lacustrine silts ..	10 ft.
	Conglomerate with limonite	3 ft.
	Lacustrine silts ..	80 ft.
2.	Fluvio-glacial conglomerate	50 ft.
1.	Boulder-clay ..	10 ft.
0.	Rhyolite.	

The chief point of interest in this section is the presence of an overthrust fault which has involved all the beds except the veneer of gravel forming the top of the terrace. In the road-cutting the effect of this fault is clearly shown where the silts have been thrust across the grey conglomerate; in the latter a bed of sandy material shows considerable distortion in the neighbourhood of the fault-plane. Below the road the line of fault becomes less clearly marked, and probably resolves itself into a series of parallel displacements; where, however, it has been thrust across the fluvio-glacial conglomerates the rhyolite shows a typical slickenside surface. The line of fault has an approximately N.N.E.–S.S.W. direction,

and the beds to the east have been tilted so that they dip at an angle of about 15° to the south-east. The throw of this fault cannot be estimated with precision owing to the absence of any recognizable horizon on both sides of the line of movement. On the west side of the fault there is no sign of the easily recognizable bed of limonitic conglomerate which appears about half-way up the whole section, so that the throw cannot have been less than 40 ft. Estimating from an average level of the junction of the silts with the fluvio-glacial conglomerate, the throw would appear to be of about 70 ft. This junction, however, is not a definite line, since the silts pass gradually down into the conglomerate.

(3.) Below the gorge the Pleistocene deposits are represented by grey fluviatile conglomerates (5), and upper fluvio-glacial beds (6), overlying the brown conglomerates (4). Sections exposed on the right bank show a thickness of 150 ft. of brown conglomerate overlain by 350 ft. of grey conglomerate, which is overlain by fluvio-glacial beds varying in thickness up to 50 ft.

MORPHOLOGY.

Tectonic Features.

Faults.

Structurally the Rakaia Gorge inlier is an intermontane basin analogous to the Trelissick basin, Big Ben outlier, High Peak basin, or any of the numerous remnants of Notocene beds preserved amongst the oldermass blocks of the alpine regions of Canterbury. Owing to the presence of the Pleistocene deposits, however, the exact positions of the bounding fault-lines cannot be accurately determined. Some such major fault doubtless passes in a north-westerly direction between the gorge inlier and the Mount Hutt Range. In the northern part of the district there is also probably some continuation of the southern fault boundary of the High Peak basin, extending in a roughly south-west direction in front of Fighting Hill.

Two minor faults are apparent in the beds of the inlier :—

(1.) As described above, the rhyolite at the lower end of the gorge has been thrust across the Pleistocene deposits. This line of displacement probably continues across the river, so that the cliff forming the north-western boundary of the old ferry reserve may be a fault-line scarp. No definite evidence of displacement of the beds on the left bank of the river is, however, available. A similar example of Recent overthrusting is that described by Morgan (1908, p. 72) in North Westland; he attributes the movement to ice-pressure in Pleistocene times.

(2.) As shown on the map (fig. 1), faulting has occurred between the rhyolite at the upper end of the gorge and the adjacent rhyolite, coal-measures, and andesites. The downthrow side is to the south, and there is no evidence of its extension on either side of the gorge. The throw is indeterminable, but probably not great.

Earthquakes.

Small earthquakes, not recorded by the seismograph at the Christchurch Observatory, are frequently felt in this district. The shocks are of a sharp character, short in duration, and without appreciable preliminary tremors. Their intensity is about IV on the Rossi-Forel scale. These movements are probably due to settling-down of the loosely compacted sediments of the Canterbury Plains, which causes slipping at their junction with the older rocks rather than to disturbances of a deeper-seated nature.

The Gorge.

The presence of Pleistocene silts and conglomerates above the gorge to a depth of at least 500 ft. below the level of the top of the barrier of resistant rocks now forming the gorge inlier requires that either (1) the bed of the river before the deposition of these beds was eroded to that depth, and therefore the barrier cannot have occupied its present position; or (2) this basin in the older rocks represents a trough hollowed out by the glacier which at one time occupied the valley, and whose deposits form the base of the Pleistocene series.

That glacial troughs analagous to the latter do occur has been amply shown by De Martonne (1911) and others. Such troughs, however, show *gently* sloping floors in an up-stream direction near the termination of the trough. In this case, allowing for later erosion by the river (which it should be noted would not greatly tend to steepen this face), the floor must have risen 300 ft. in 10 chains—*i.e.*, possessed a grade of 1 in 2.

It would therefore seem that the later geological history of the district has been somewhat as follows:—

1. After emergence caused by the Kaikoura orogenic movements, erosion continued until a topography little less mature than that of the present was produced.
2. An extension, followed by retreat of the Rakaia valley glacier, took place, and the above-described boulder-clay was deposited.
3. Through upward movement of the block which now forms the gorge inlier, at a rate that was quicker than the river could keep pace with in cutting down its bed, a lake was formed in which were deposited the silts and conglomerates now overlying the lower boulder-clay. It should be noted that the part of the barrier now forming the south-eastern part of the inlier—*i.e.*, the rhyolite of the island and surrounding parts—at one time must have been the highest part of the barrier, since the silts are found as far down-stream as Pipeclay Gully.
4. Aggradation continued until silts and gravels filled the valley to about the level of the present highest terrace.
5. About the time when this point of maximum aggradation was reached the glaciers again advanced, and the second glaciation of the district as described above took place. Upon the retreat of the glacier, erosion of the valley-floor set in, and the present gorge of the river was carved out with the terraces as described below.

A feature of morphological interest shown in the gorge is the influence of the structure of the beds upon the form of the course of the river. At the upper end it runs parallel with the strike of the coal-measures along the line of their junction with the older volcanics. Upon leaving the igneous rocks it makes a right-angle turn and follows the dip of the coal-measures until diverted by the less easily eroded igneous sill; from here it follows roughly the strike of the coal-measures as it swings round in the basin-shaped fold until a point is reached where it breaks across the volcanic rocks forming the lower wing of the fold.

The Glaciation.

Evidence that the valley of the Rakaia River has during Pleistocene times been occupied by an extensive valley-glacier is afforded by (1) the presence of glacial deposits, (2) the character of the existing topography. Some descriptive account of these features has been given above, and this

section will be confined to reconstructing that part of the geological history of the period which will throw light upon their origin.

As shown when dealing with the Pleistocene deposits, there are two independent glacial deposits in this series which are separated by a considerable thickness of normal fluviatile or lacustrine sediments. It therefore follows that there must have been at least two periods in which ice extended as far down the Rakaia Valley as the present gorge.

Evidence of fluctuations in the severity of the glaciation in New Zealand is extremely scanty, and it is generally considered that there has been but one great advance of the glaciers, followed by a gradual retreat to within their present limits. Speight (1921) shows that the notched spurs of the Upper Rakaia and Waimakariri regions give evidence of only one period of ice-advance. The extent of this intervening retreat may not have been great, but the thickness of intervening sediments, which may be, as above the gorge, more than 700 ft., shows that the duration of the interglacial phase was not short.

Of the extent of the first advance of the ice little can be said, since its deposits, which are visible only about the gorge (where they have doubtless been elevated to an exposed position by subsequent earth-movements) are the only traces of its existence. Results of the erosion of the ice of this period upon the topography have been completely obliterated by the action of the subsequent extension. The thickness of the lower glacial deposits, moreover, gives little indication of the intensity of that advance, since it is impossible to say whether they represent accumulations at a terminal face during a stationary period of the glacier, or whether they are merely the results of deposition along a steadily-shrinking ice-front.

Of the second extension more may be deduced. As shown by Haast (1879), the ice probably reached, when at its maximum, as far as Woolshed Hill, and spread out in piedmont form across the Canterbury Plains from the neighbourhood of the Glenroy Saddle to the south-eastern end of the Mount Hutt Range.

It is of interest, in considering the character of this glacier in its final extension, to notice how the loosely consolidated Pleistocene deposits which form the floor of the valley have resisted the erosion of this mass of ice. If the erratics found on the north-western slopes of Round Top are due to this extension, the ice in this place must have had a thickness of at least 500 ft. Even if these erratics were due to the earlier advance, a considerable thickness of ice must have been present to cause its extension as far as the Woolshed Hill morainic deposits. Despite this mass, however, the sediments of the valley-floor were not entirely scooped out. This occurrence seems to lend support to the theory that the action of glaciers on the floors of their valleys exerts a protective rather than erosive influence.

The Terraces.

The terraces occurring above and in the gorge are most easily explained as due to the slow reduction of the barrier of resistant rock. Their heights roughly alternate on either side of the river, as is characteristic of barrier terraces. Of especial importance in the preservation of the terrace-remnants about the gorge are the effects of bluffs and ridges of the more resistant rock, which have acted as turning-points for the stream in the course of its entrenchment. Illustrations of this preservation are shown in Plate 18, fig. 2.

The terraces above the gorge barriers may thus be explained without the assumption of any change in base-level due to change in position of the

land relative to sea-level; the numerous terraces below the gorge, however, present some difficulties. The explanation advanced by Hutton (1873) and supported by Marshall (1912), that they are normal river-terraces due to emergence, cannot be accepted without question.

Speight (1907) shows that there is a lack of supporting evidence for a theory of recent elevation of the central Canterbury area. Such movement would also necessitate the deposition of the upper beds of the gravels of the plains under marine conditions. As yet, however, there has been no evidence adduced to show that any part of the plains has been formed of delta or marine deposits. Speight, concluding that these terraces are not due to uplift, suggests that the effect of a diminution in the supply of waste would be to cause an entrenchment of the rivers below the levels of their fans at their apices. Whether or not a stream will erode its bed in any place depends, however, upon the gradient of the stream in that place; other factors, such as load carried, merely determine the rate of erosion. In accounting for these terraces it is therefore necessary to explain how a change in gradient occurred by which the river was enabled to erode its own deposits.

In tracing the history of a fan formed by any stream the following two stages may be noted:—

(1.) In its earliest youth the stream, passing down a steep bed, with consequent high velocity and carrying a heavy load, builds up a fan upon reaching the edge of the immature country; as this process goes on the fan is built up until its apex is level with the point where it leaves its rocky bed.

(2.) As erosion continues the fan is extended to a less convex shape, with lower angle of declivity, at the same time the bed of the stream in the alpine area reduces its grade. The point where the stream leaves the rocky

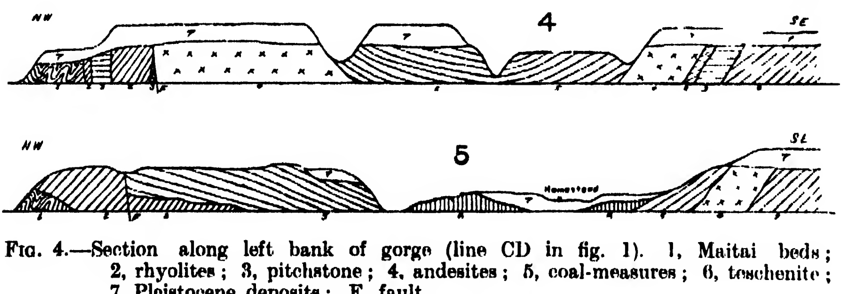

FIG. 4.—Section along left bank of gorge (line CD in fig. 1). 1, Maitai beds; 2, rhyolites; 3, pitchstone; 4, andesites; 5, coal-measures; 6, teschenite; 7, Pleistocene deposits; F, fault.
FIG. 5.—Section along right bank of gorge (line EG in fig. 1).

bed to pass over the fan will therefore also be lowered. The river must then begin to cut into the top of its own fan-deposits. As this process continues, residual terraces will form at the top of the fan, which will possess the feature of barrier terraces—that the remnant on either side of the river will not correspond in level but will form an alternating series. These terraces, moreover, will decrease in height above the river-level when traced towards the fringe of the fan.

Applying this hypothesis to the terraces of the Rakaia River below the gorge, the observed facts appear to be explained—(1) The terraces are discordant in level on either side of the river; (2) they decrease in height above the river-level when traced towards the sea. In the Rakaia River the terraces have completely disappeared about twelve miles inland from the coast.

5. CONCLUSION.

The following is an outline of the geological history of the Rakaia Gorge district:—

1. *Permian* or *Trias:* Deposition of greywacke, shales, &c.
2. *Lower Cretaceous:* Orogenic activity, with contortion of Maitai beds and emergence of land-surface.
3. *Middle Cretaceous:* Period of erosion when land-surface reduced to peneplain; eruption of rhyolites and pitchstones followed by andesites and andesitic breccias.
4. *Upper Senonian:* Marine transgression, with deposition of coal-measures, and probably followed by more or less continuous deposition until Pliocene times.
5. *Tertiary:* Intrusion of teschenite sill into coal-measures.
6. *Pliocene:* Orogenic movements characterized by block-faulting and causing emergence of the land-surface.
7. *Pleistocene:* Period of erosion giving rise to present topography, and including two periods of extension of the Rakaia Valley glacier as far as this district.

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Considerations relative to the Age of the Earth's Crust.

By the Hon. Sir FREDERICK REVANS CHAPMAN, formerly a Judge of the Supreme Court of New Zealand.

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IN considering such questions as this we may roughly divide our knowledge of relevant facts into two classes— namely, (1) things which are demonstrated, and (2) things which are proved by the balance of evidence. They are not really two classes, as the inferior value of the second is only a question of the strength of the evidence.

1. Under the first head we have—

(1.) Life began on this planet : if it also began elsewhere, that does not concern us. There could be no actual connection between the life that began here and the life we may guess began elsewhere. Of such life we have no proof, and if we could import living beings from elsewhere it would not alter the problem.

(2.) Life began at some date : that is to say, there was a time in the earth's history when it was too hot to allow the beginning of life, as we understand the term, to be possible.

(3.) Changes on the hot surface of the planet resulting in a cool surface and condensed waters made the advent of life possible. No form of life that we can conceive of, and consequently no form of life as we understand the expression, can exist on the sun or on the glowing stars, and it is improbable that it exists on Mercury or Saturn. Ascertainable conditions suggest this improbability.

(4.) It began in a sense spontaneously—that is to say, under some natural impulse governed by antecedent conditions affecting the matter which became a living thing. We cannot scientifically postulate any other mode of beginning. This fact may belong to the first or to the second class. We accept it as a fact because reason teaches us to regard it as proved by substantially cogent evidence negativing any other hypothesis.

(5.) Save that we must shut off the early stages of the earth's existence when its surface was unfit to support life, we cannot do more than conjecture when it began. We can only collect such evidence as is available denoting periods when life existed. We must now recognize a tendency to push this further and ever further back in the history of the planet as our actual knowledge increases.

2. Of the facts made out by strong if not cogent evidence we have—

(6.) Life began by a concourse of matter under chemical, physical, and perhaps electrical conditions favourable to certain aggregations of matter attaining a quality which we call life. Personally I do not see how this can be effectively disputed. It cannot be denied save by substituting something more probable for this hypothesis. The further we go back in the history of speculations as to the origin of life—or, rather, of living beings—

the more crude do we find these speculations. Milton describes the process from his point of view, veiled as to the origin but visible as to the result :—

> The grassy clods now calv'd ; now half appear'd
> The tawny lion, pawing to get free
> His hinder parts, then springs as broke from bonds,
> And rampant shakes his brinded mane ; the ounce,
> The libbard, and the tiger, as the mole
> Rising, the crumbled earth above them threw
> In hillocks : the swift stag from underground
> Bore up his branching head : scarce from his mould
> Behemoth biggest born of earth upheav'd
> His vastness : fleec'd the flocks and bleating rose,
> As plants : . . . —*Paradise Lost*, Bk. 7, 463.

If seriously produced in our time, this description of the creation would provoke a smile ; but I feel inclined to regard it with respect. It throws into poetic form the view of creation which for a century and a half after Milton wrote was the only known view.

(7.) It seems to me more reasonable to conclude that the aggregations of matter so conditioned as to be ready to receive life were very small rather than large. This conclusion I regard as of the utmost importance in connection with the question of geological time. We now know of the existence of living things so small that it is far under the mark to say, as was recently said of typhoid germs, that a thousand millions of living beings only aggregate to the size of a small pin's head. Why should we assume that they have degenerated to this size rather than that they were brought into being on this or on a much smaller scale ? The presumption appears to me to be in favour of my proposition. Under this head we look to presumption until we can have demonstration.

If we venture without the support of any evidence to assume that life began in creatures or aggregations of greater size, how far are we to go ? Are we to support the Miltonic creation ? Where are we to make our assumed starting-point ? I submit that in any case we cannot intelligently postulate anything larger than something still only perceptible with the aid of a microscope. Against a contrary assumption is the fact that certain diseases appear to be caused by poisons emitted by micro-organisms so small that our most vigilant observers have not yet seen them. Smallpox is one of these diseases. It begins and runs a course so like that of other fevers that, using our reasoning-powers, we conclude that it begins as other fevers begin, under the influence of a minute living organism capable of creating or acquiring and exuding a poison. Other familiar fevers, such as scarlet fever and measles, have a similar origin and run parallel courses. One of the most remarkable is trench fever, produced by organisms which are parasites in lice. This organism, like the others, has escaped visual observation. It has, however, been trapped and utilized to render patients immune from its own attacks. It is a reasonable conclusion from what is known of it that it is a highly specialized creature of ultra-microscopic dimensions.

These experimental observations were made during the late war, but more recent experiments have produced definite visual results. I need not go into the subject of ultra-microscopic observation and photography beyond mentioning that this latest triumph in scientific methods results in our obtaining visual cognizance of things that are too small to be seen under the most powerful microscope used in the ordinary manner. By this means it has been found that the microbe of foot-and-mouth disease, which has again appeared among cattle in Europe, belongs to the little-known group of "filter-passers," organisms so minute as to be inseparable

by a Pasteur filter from a liquid containing them. This discovery is the work of two Dutch scientists, Paul Frosch and H. Ahmen, who pronounce the causative organism of this disease to be a yeast-like organism propagated by budding. Grown on a solid medium it gave rise to colonies from 7 to 8 microns in diameter. A micron is a millionth of a metre. The investigators report: "With high magnifications and the use of light of the shortest possible wave-length it was found possible to get photographs of individuals of the organism which proved to be bacteria with an estimated length of about one-tenth of a micron." (*English Mechanics*, 11th July, 1924.)

It is not essential for my purpose to go further into this subject, as it cannot be determined to what extent the existing inhabitants of the earth are descended from creatures as small as this; but these investigations render it probable that others of the disease-producing germs are of this minute character, and that until reasons to the contrary are shown it is reasonable to assume that life began in creatures of very minute size.

The organisms which produce this and other diseases which I have mentioned are not likely to be of the original forms into which life was infused; they are all highly specialized poison-producers. In the case of foot-and-mouth disease the organism cultivated to the twenty-sixth generation has been found to retain its special virulence.

It seems to me not unreasonable to conclude that before life thus specialized as we know it began, countless generations in more primitive form had preceded the specialized forms, and that specialization involving increased size may have begun in forms more primitive than any we know.

At one time the habit prevailed of referring to amoeba as a primitive form; it is, however, a relatively large specialized form.

(8.) Is it not then a reasonable interpretation of the evidence to suggest that forms of life exist of the minute dimensions at which such forms, and perhaps all life, began?—that is, assuming that life did arise from organic matter. We need not assume that those very forms do not still from time to time come into existence. All that we can say is that we are wholly ignorant on the subject.

This course of reasoning may without violence even carry us down to those objects of which we now have actual cognizance, which we call ultra-microscopic objects.

It is not necessary, nor is it reasonable, to adopt any positive view on the actual question of size, but I think I have shown reasons for regarding it as probable that some of the germs of disease and other germs are of ultra-microscopic dimensions or of dimensions of a similar order when compared with visible living beings. I am content, however, to start with the assumption that life began where we reasonably conclude that it exists, because the qualities of beings that produce certain results are so like those of beings that we can see as to convince us that they are living beings. If that involves too great a draft on the imagination, then I am content to go down no further than to the size of beings which we can actually see—perhaps far below the size of the typhoid bacillus.

(9.) On these grounds I draw the conclusion that life began on a minute scale in that partly explored world of which we gain more knowledge every day. I speak of a conclusion, but I admit that the subject is so far speculative that any conclusion is liable to be upset. It would, however, be most difficult to explain away the case of the germ of foot-and-mouth disease, or to assert on reasonable grounds that it is a solitary case. In this connection it must be borne in mind that I am not writing on the beginnings

of life, but am attempting to discuss a different subject—namely, a line of inquiry as to the age of the earth's crust. Any one who found it impossible to believe that life originated as I have suggested, and held that the balance of evidence led to an entirely different conclusion, would not find that to discard this would affect the main theme of this paper. Darwin never found it necessary to discuss the subject of the origin of life. He dealt with the history of organized creatures. I am -I hope, with becoming modesty—discussing a parallel topic. It is therefore quite incidentally that I pause to point out that great chemists and biologists—I need only refer to such names as John Tyndall and Henry Chorlton Bastian may be said to have advanced a long way apparently in the direction of showing how life began. It is, however, sufficient to say that their brilliant experimental efforts, while producing what must be regarded as organic from inorganic substances, and going far to break down the barrier between the inorganic and the organic, have not resulted in the production of living things. Speaking with the greatest respect of these and other great men of science, I find myself driven to say that while throwing down one barrier they have perforce left the other standing. The synthetic production of organic substances by Tyndall has been immensely advanced and widened in the hands of his disciples, but we still await the Frankenstein who can make them live and move and reproduce their kind. We do not know the origin of life; we can only speculate as to whether we ever shall know it. For the present, however, on mere arithmetical grounds based on the ordinary law of probability, and opposed by no more rational conclusion, I have provisionally formed this conclusion :—

(10.) When we attempt to speculate on the age of this planet as the home of living things we are forced to consider the line of reasoning with which I started. Any one may reject it, but he ought to do so either by showing some fallacy appearing *ex facie* or by producing evidence displacing it. That is the course of reasoning by which any scientific proposition other than a mere dogma must be destroyed or displaced. Incidentally, recent observations in the field of palaeontology may be referred to.

It has long been the habit of geologists to divide the stratified rocks of the earth into two categories. The oldest was called Azoic, when and because, so far as observation went, it was devoid of indications of past life. The second embraced all the rocks in which fossils and other evidence of life were found, from the earliest to those at present in course of formation.

Some geologists have attempted to give the relative thickness of the rocks in these two categories. More than one published scale shows the Azoic rocks as equal to one-half of the whole known series of stratified rocks.

The pre-Cambrian rocks of Scotland are 8,000 ft. to 10,000 ft. thick, resting on a further series of great thickness. A thick series of slates and phyllites lies below the oldest Palaeozoic rocks in central Europe, with coarse gneisses below. In America, about the great lakes, a vast succession of rocks of pre-Cambrian age has been classed as forming six successive. layers of great thickness. These have received names, the lowest being the Laurentian. Some of them have, however, been found to contain traces of living organisms. Since 1910–11, the date of the eleventh edition of the *Encyclopaedia Britannica*, further explorations have yielded remarkable results. Some of these are summarized in the recently added *Supplement* of 1922. In this summary an attempt is made to apply a time-scale to the whole period covered by the growth of stratified rocks.

The term "Azoic" is not used, but, allowing sixty millions of "time units" for the building-up of all the periods, one-half is allotted to the pre-Cambrian ages. Here below the Laurentian is a vast assemblage of rocks awaiting further examination and exposition. When this stupendous series of old-world rocks is contemplated it is not surprising that geologists stubbornly stood out against the suggestions that limited the age of the earth's crust to a few tens of millions of years. In discussing the question of age the biologist necessarily goes hand-in-hand with the geologist.

It is when attempts are made to measure time by years that the greatest difference arises between the authorities. Here the physicist claims a voice, and in his present mood entirely reverses the contentions made a few decades back, when he relied on mathematical calculations which appeared to give but a relatively short life, both in the past and in the future, to the heat of the sun. Thus "taking the Lead as all produced by Uranium at the rate [elsewhere] above given we get an age of 925 million years. Some minerals from other Archaean rocks in Norway give a rather longer age . . . the upshot is that radio-active methods of research indicate a moderate multiple of 1,000 million years as the duration of the earth's crust as suitable for the habitation of living beings, and that no other considerations from the side of pure physics or astronomy afford any definite presumption against this estimate." (Lord Rayleigh, 1921.)

This method, it is said, carries back the appearance of *Eohippus*, the oldest form of horse, some thirty million years. Obviously this stretches the Tertiary ages in an enormous degree, making them cover seven or eight times as long a period as was not long since regarded as necessary. I have often wondered why the geologists and palaeontologists spoke of the Tertiary ages as extending over four million years. Why not forty million? I had to be silent in the presence of such unanimity—for unanimity there was. I am afraid that I am growing less modest as my years advance. Charles Dolittle Walcott, one of the most successful geological explorers of modern times, appears (1893) to speak of three million years for the age of mammals, while Joseph Barrell (1917) calls for fifty-five or sixty-five million years. The date (1893) given for Walcott's deduction was long prior to his remarkable discoveries. The modern tendency undoubtedly is to recognize immensely longer periods for the building-up of the rocks than were admitted a couple of decades back. Opinion on this comparatively new subject is, however, necessarily in a state of flux; we may not unreasonably hope for something more like demonstration as data accumulate and methods improve. Recent investigations by Walcott have revealed evidence of primitive life in the pre-Cambrian (Proterozoic) rocks of North America. In Montana, at a depth of nearly 10,000 ft. below the earliest Palaeozoic rocks (Cambrian), he found evidence of ancient reef deposits of calcareous algae which ranged upwards through 2,000 ft. of strata. The general barrenness of pre-Cambrian rocks is no doubt attributable to their extensive metamorphosis, presumably under the influence of heat-producing upheaval and other movements. This would tend to destroy everything but the hard casings of calcareous plants and of animals similarly protected. We need not, however, despair of the discovery of what may be termed the portraits of some of the even earlier denizens of the earth. Corals and sponges represent advanced structures—for Walcott has added to our knowledge of such life the discovery even of a monad or bacterium allied to *Micrococcus* living in pre-Cambrian times. Bastian had in 1910 referred to the fact that B. Renaut had found traces

of *Micrococci* and *Bacilli* "even as low as the upper Devonian strata." This discovery has been immeasurably surpassed by those of Walcott. If any value can be attached to the presumptions I have ventured to put forward, even a *Micrococcus* may from its structure be regarded as a creature which has already advanced in point of size at least far beyond the most primitive forms of life.

These considerations encourage further investigation, which may carry the discovery of evidences of life not only down throughout the Laurentian age but into and perhaps through a period equally long which lies below it. It is impossible now to speak conclusively of an Azoic age so long as we are dealing with stratified rocks.

Incidentally it must be allowed that, apart from the suggestions of the physicists, we can have no actual data for fixing the age in point of time of the earliest rocks until we have means of determining the rate of the deposit of strata. This may, but need not necessarily, have been more rapid in earlier than in later times. There may have been, and probably was, a vastly greater rainfall, causing a more rapid destruction and redeposit of the surface soils. We may also have to reckon on tidal action on a far more active scale if the history of the rocks carries us back to a period when the moon was appreciably nearer to the earth than at present. Before this can be touched we must come to an understanding with the astronomer.

I may now briefly refer to certain forms of which we have definite knowledge, and concerning which we may fairly speculate as to their having in the course of ages grown up in successive generations from some of the smallest to some of the greatest living creatures.

The recent expedition to the Ross Dependency found it necessary, for economic purposes, to weigh their captures. The great blue whale was found to weigh 150 tons. If the assumption with which I have started has any foundation, this animal by a long process of evolution may have progressed from an ancestor a thousand million of which would build up a speck the size of a pin's head. This is not proved, but it is not disproved, and it lies within the limits of reasonable argument. There are, of course, difficulties. A dormouse weighing an ounce has presumably an analogous history. In its structure it has an obvious affinity with its great congener. They are both mammals, and each has seven cervical vertebrae in common with almost all mammals. In the course of its evolution it has been found to be to the advantage of the race to which it and its ancestors belonged to remain small, while it has been to the advantage of the whale branch to attain and retain an immense size. Such differences for protective and generally benefit-conferring purposes are familiar throughout animal life. Trees great and small afford a similar illustration. The difference between the kiwi, living in dense forests in New Zealand, and the moa, formerly frequenting open plains, is another familiar instance, the relation between these two birds being much closer than in the first-mentioned instance—so close, indeed, as to leave open no question as to their common origin.

As to the rate of growth in the course of evolution, of which we know so little, we are not confined to one group in our search for animals of immense size. Great developments are scattered through the ages immediately preceding our own. Our largest surviving land mammal is the elephant, and in no other order is there now a near approach to its size. *Baluchitherium*, the vertebrae and limb-bones of which were found

in the Upper Oligocene of Baluchistan, was probably much larger. In Pleistocene times the ground-sloths of South America rival the elephant and rhinoceros in bulk. The *Megatherium* was 18 ft. long, and its skeleton was of a most ponderous character. But perhaps the most remarkable of the mammals of the pampas is the great armadillo, *Glyptodon claviceps*, with the enormous weight of armour in separate plates over its body, head, and immense tail. It was 9 ft. long. The ponderous carapace indicates the prolonged operation of some cause or impulse, not solely connected with its feeding-habits, which had secured the preferential persistence (in survival of the retention) and progressive expansion of this monstrous development. Changes in the climate of this region probably produced a scarcity of food which led to the extinction of this great and varied fauna. The geological record as disclosed to us gives us at best but a hint in the shape of evidence. The pictures of past life, consisting not merely of skeletons, but of the undigested contents of the stomachs of the animals of the past, and even the fossilized eggs of the *Dinosaurus* recently (1924) discovered in northern China, are continually illuminating our means of study; but what lies buried beneath whole continents of land surface is only here and there disclosed by almost accidental breaches of that surface. What lies beneath vast stretches of ocean like that which separates southern Asia from Africa must remain for ever undisclosed so far as the human race as we know it is concerned. Thus far I have drawn my examples from the Tertiary period, with its specialized mammalian fauna.

We may, however, leave this and leap backward over the immense and unmeasured interval of time which separates the age of mammals from the age when the great reptiles were dominant. This interval is still unbridged. The prodigious development of the saurian fauna is the wonder of the geology of that great era. The largest surviving saurians, the crocodiles, are simply trivial when compared with their mighty predecessors—ancestors in any direct sense we can hardly call them.

The *Brontosaurus excelsus* of the upper Jurassic of Wyoming must have been fully 70 ft. long and 25 ft. high. Though its bones were lighter in structure than those of the great land mammals, it was built to walk on land, carrying its enormous weight on sufficiently stout legs. In the same region and of the same period is the *Diplodocus carnegii*, 80 ft. in length. Its skeleton shows that it must have had an immense muscular development to enable it to carry with comfort its enormous neck, projecting far beyond its body.

These two examples show size and weight, competing with that of our modern whales, carried by animals walking on land, even though living generally in the more sustaining medium of shallow waters. It is enough to mention these two examples of great vertebrates of the far past as showing that in that remote age great and wonderfully perfect development was achieved.*

To grasp the significance of these illustrations of the age in which the great saurians dominated the waters, the earth, and the air, we have to

* Since this paper was written further information has come to hand respecting the extensive discoveries made in recent times in the Tanganyika area of South Africa. Amongst other important results these finds make it clear that the *Gigatosaurus*, with a humerus more than 7 ft. long, must have far surpassed in size any saurian or other form of animal theretofore revealed to the geologist. At least one writer claims for it a size double that of *Diplodocus carnegii*.

try our best to appreciate the immense lapse of time which has occurred since the Jurassic rocks were laid down to the enormous depth at which we find them.

I can only briefly—and, I must admit, in a most unsatisfactory way—refer to what I may term the arithmetic of the case. It is a subject which opens up a field for endless speculation and inquiry, but, so far as I know, it has not up to the present been very comprehensively attacked. How many generations are required under given conditions of temperature, environment, &c., to raise from an invisible microbe a *Brontosaurus* or a whale ? The problem is a stupendous one, but it is one that cannot be passed over, and is one which will, I think, receive more attention in the future than it has received in the past. If a creature the size of a typhoid bacillus bred another which doubled its weight in the first generation, and again added its original weight in each succeeding generation, its progeny would by successful development reach the size of a pin's head in, say, for example, a thousand million generations. If this went on unswervingly, and there were ten generations in each year, the result would be achieved in something like a hundred million years. It is, of course, mere guesswork to talk of ten generations in a year; there might be a hundred. On the other hand, it is a bold step to suggest that life has run so smoothly that in each generation the descendant of any particular microbe added its original weight to its progeny. Probabilities are against this having occurred over the whole series of generations. If the ancestry of the whale could be traced to a creature of the earliest date of the age of mammals, or even to some creature approaching the mammalian type as small as those we are told are found as we approach the Eocene, and that ancestor were found to be no more than an ounce in weight, then it has in a given period, not stretching back into the great age of saurians, so increased its bulk that its descendants of to-day are more than five million times the weight of their ancestor. There is, moreover, here in the later stages no question of ten generations in a year. Some of the great mammals do not produce at the rate of one a year, after some years have been spent in reaching maturity. Such figures relate to a comparison in weight between two creatures of the relative sizes, say, of a mouse weighing an ounce and a whale weighing 150 tons. But without going into actual arithmetic it may be pointed out that the disparity in weight between a creature the size of a typhoid bacillus and one the size of a mouse is vastly greater; while between the size and weight of the invisible microbe of foot-and-mouth disease and the comparatively gross typhoid bacillus there may be a disparity approaching either of the above. It is difficult to grasp comparisons of sizes in dealing with such matters.

The growing importance of the subject of examining the minutest forms of life is, however, attested by the discoveries of Dr. F. d'Herelle, of the Pasteur Institute, which came under my notice while I was revising this paper. It is found that certain bacteria which propagate diseases—perhaps hitherto regarded as not curable—so small themselves that they are only revealed by means of a microscope of 3,000 magnifying-power, are preyed upon and destroyed by smaller parasitic organisms of the "filter-passer" type. So minute are these that they are described as "just as small in relation to ordinary bacteria as a flea is to a calf." These have now been styled "bacteriophages." They have already been utilized for the destruction of the bacteria of persistent dysentery, and their discovery, isolation, and culture give promise of a revolution in the treatment of various

diseases. (*English Mechanics*, 19th September, 1924.) What occurs to me in reading of such organisms is this: Are we to assume that they have retrograded from predecessors of larger size, or is it not more probable that they are rather in the vicinity of the size at which most lines of organized beings have received life? Geological history, and analogies derived from it, give us the only clue we have at present to the answer. I will leave it to others, curious of arithmetical details, to calculate the relative weights or sizes of the various creatures involved in this discussion from a "filter-passer" to a *Brontosaurus* or a whale.

As we go down the geological ladder we find, as a general but not universal rule, that the creatures are getting smaller and smaller. It is true that examples of the smallest are always with us, while, as in the case of the giant saurians, the largest are sometimes left by the way; but the rule remains good until we find ourselves groping with Walcott among the immeasurably ancient rocks of Montana in the hope of here and there finding a legible stain or similar sign that life was once there. If our giant vertebrates are not descended from minute ancestors of those ages, we are left without means of even guessing where they came from. If they are so descended, have we not then to face the time-problem on some such lines as I have indicated? The evidence points to the mammals having originated as small rat-sized creatures in the Jurassic and possibly, but doubtfully, in the Triassic period. That is to say, some of the saurians of the earlier period present some mammalian affinities; but to give this fact a definite value in this connection it would be necessary to show direct ancestral descent. It is considerations such as these which have led me to wonder whether our great geologists are right in assigning a period of only a few million years to the whole Tertiary age. I again most respectfully urge that it is probable that too much importance has been attached to evidence which appears to enforce this limitation.

I have presented certain problems of simple arithmetic. The least that can be said of them is that they deserve serious consideration. In doing so I have ignored evolution *per saltum* as I have ignored the Miltonic creation. I am quite prepared to admit that there may be an occasional sudden advance in size. We have, however, no knowledge of such a phenomenon. I am also quite alive to the observations of geologists who in certain periods of the earth's history find evidence of rapid expansion of groups of animals, as if new genera and species were appearing at an accelerated rate: Deprét has spoken of an "explosion" of forms in the ammonite genus *Neumayria*. Moreover, we can no more insist on a universal law of uniformity in the matter of speed of variation than on any other supposed fact of which we have no actual knowledge. What we do know as a general rule to be deduced from the evidence is that evolution as a whole has been slow and gradual, especially perhaps when dealing with large bony structures. When, therefore, we find in a single group what we take to be evidence of a more rapid rate of change we note it as something exceptional, accentuating, without contradicting, the general rule.

My modest efforts to illustrate what we require in the shape of vast measures of time are merely tentative, but again I claim that they call for discussion. My own impression is that when the matters to which I have addressed myself receive from competent investigators the consideration they deserve the result will emerge in the shape of conclusions as to the age of the crust of the earth of a totally different order from those heretofore admitted. My own opinion as to how such inquiries and discussions will probably eventuate is sufficiently disclosed in the above.

Cretaceous Plants from Kaipara, N.Z.

By W. N. EDWARDS, M.A., British Museum, London.

Communicated by P. Marshall.

[*Read before the Wellington Philosophical Society, 27th August, 1924; received by Editor, 28th August, 1924; issued separately, 6th March, 1926.*]

THE following notes are based on some specimens collected by Dr. P. Marshall, who kindly handed them to me for examination. They all come from Bull's Point and Batley, Kaipara Harbour, New Zealand, and the geology of the district has been fully dealt with by Dr. Marshall himself.

Though the plants do not give any indication of their exact horizon, they are associated with ammonites which point fairly definitely to an Upper Senonian (Campanian) age.* Most of the plants so far discovered are either fragmentary or belong to form-genera which are of little use for correlation purposes; they are, however, of considerable interest botanically, more especially as there are some petrifactions as well as impressions.

They occur mainly in hard nodules with an irregular fracture, from which it is difficult to obtain complete specimens; and, moreover, the plants were evidently in a fragmentary condition before fossilization. The impressions are partially petrified; thus, in the case of the fern *Taeniopteris batleyensis*, sections reveal to some extent the structure of the midrib, while collodion imprints of some of the leaf-fragments show the outlines of the epidermal cells. The araucarian leaves show the rows of stomatal pits very clearly, and can also sometimes be sectioned fairly successfully, while some of the araucarian wood is very well preserved.

One of the nodules is of great interest, for it consists largely of petrified vegetable debris in a sandstone matrix, and at once suggests comparison with plants containing nodules from other places. In its general structure this nodule closely resembles those from Upper Cretaceous beds of Japan described by Dr. M. C. Stopes (1909), from which a large and interesting flora was obtained (Stopes and Fujii, 1910). The matrix of the Kaipara nodule (kindly examined for me by Mr. W. Campbell Smith) consists of very angular quartz-grains in a calcareous cement together with a few crystals of feldspar, traces of mica, some green flakes of chlorite, and a very few grains which might be glauconitic. All these constituents are probably of detrital origin. Scattered through the matrix are abundant petrified plant-fragments and a few Foraminifera and other shells. Sections of other nodules showed a very similar mineral structure (sometimes more finely grained), but with very little plant-debris except for highly comminuted tissue-fragments. The Japanese nodules also vary in the amount of the plant contents, some containing only shells and no plants, while only a few have the fragments thickly massed. The Kaipara nodule differs from the Japanese in being slightly coarser-grained, with rather more quartz, while the plant-remains are not so well preserved. Dr. Stopes gives a detailed

* The collections of ammonites include the well-known form *Pseudophyllites indra* and the local representative of *Gaudryceras kayei*; also species of *Puzosia*, a form close to *Acanthoceras rotomagense*, and a form close to *Phylloceras velledae*. It appears, therefore, that if a single horizon is represented it must be somewhat lower than the Campanian. The question is discussed in a paper on "Upper Cretaceous Ammonites" in this volume.—P. MARSHALL.

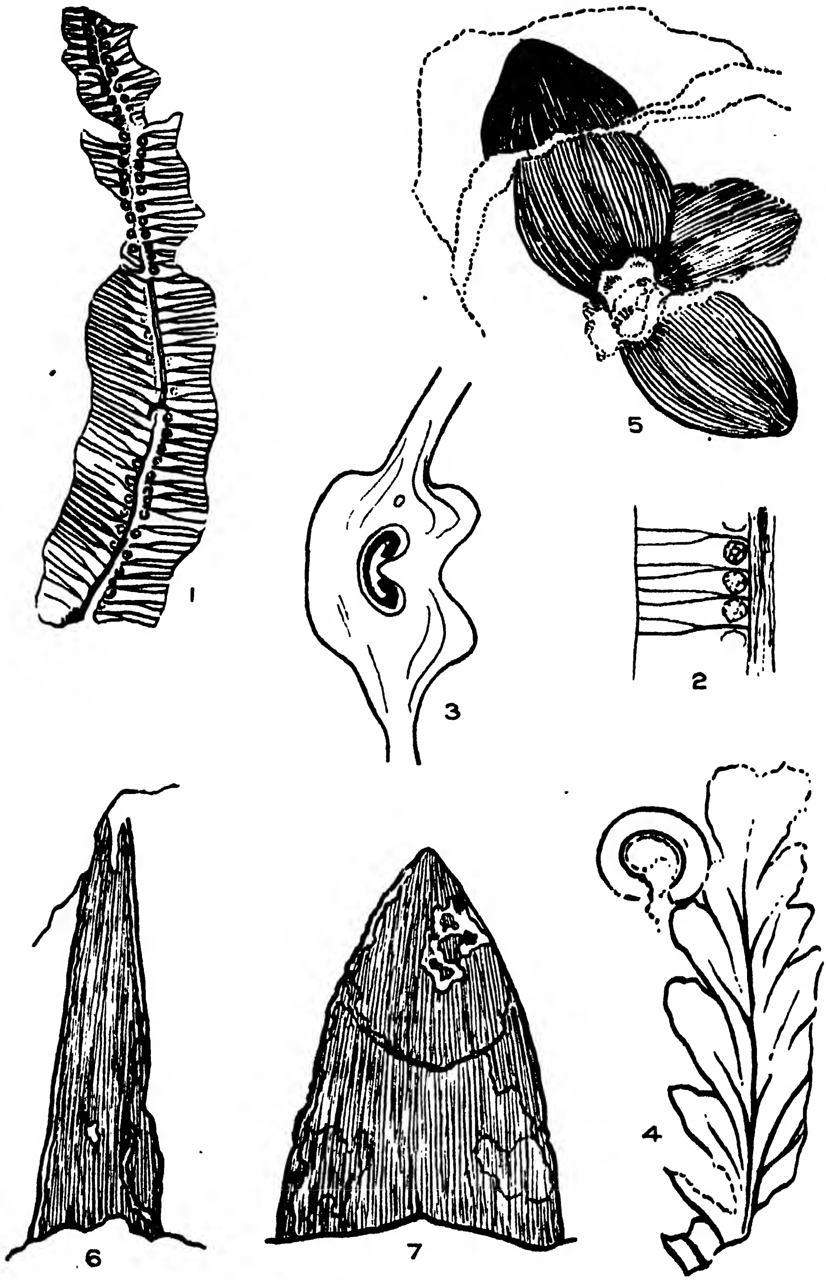
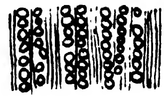
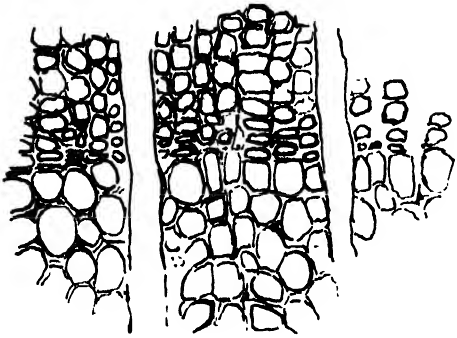


FIG. 1.—*Taeniopteris batleyensis* n. sp.
FIG. 2.—*Taeniopteris batleyensis* n. sp. The sori are very worn, and their structure is doubtful.
FIG. 3.—Fern-petiole from stem of *Dadoxylon*. Diagrammatic view of transverse section.
FIG. 4.—*Sphenopteris* sp.
FIG. 5.—*Araucarites marshalli* n. sp. Leaves attached to axis.
FIGS. 6, 7.—*Araucarites marshalli* n. sp. Single leaf.





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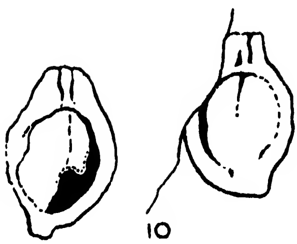

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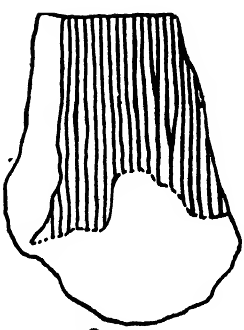

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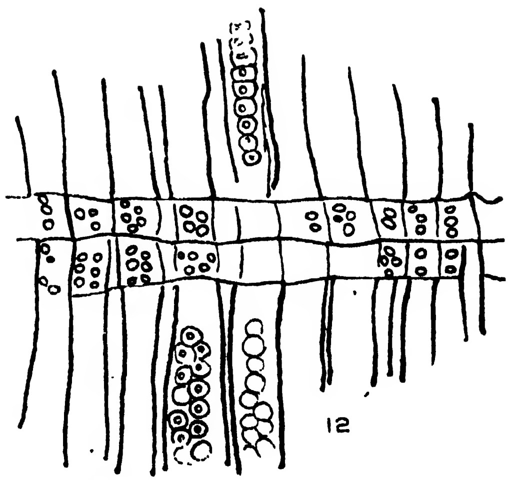

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FIG. 8.—*Araucarites marshalli* n. sp. Small portion enlarged to show rows of stomatal pits.
FIG. 9.—? *Dammarites* sp.
FIG. 10.—*Carpolithus zeelandica* n. sp.
FIG. 11.—*Dadoxylon kaiparaense* n. sp. Part of transverse section magnified, showing a fairly well marked annual ring, which, however, was not visible to the naked eye.
FIG. 12.—*Dadoxylon kaiparaense* n. sp. Radial section.
FIG. 13.—*Dadoxylon kaiparaense* n. sp. Tangential section.

comparison of her nodules with the coal-balls and roof-nodules of the English Carboniferous beds. The resemblance is greater to the latter—which, however, are much finer grained, and contain very little quartz, while the plant-fragments are never closely packed. The differences are due to differences in deposition: the plants in the roof-nodules had drifted and been sorted out, but "the numerous minute fragments of the Japanese nodules . . . could neither have drifted far nor long before they were covered and preserved in that potent preservative and petrifying solution, sea-water" (Stopes, 1909, p. 203). The granular Kaipara nodules with their marine animals were also obviously formed fairly near the shore where detrital matter was accumulating, but the plants had perhaps drifted a little farther, for they had decomposed more than the Japanese plants, so that only pieces of wood and the thicker and more resistant leaves have been at all well preserved. There are at Kaipara a few fairly large stem-fragments (see below), but in the nodule which has been particularly noticed here there are only small scraps of coniferous and dicotyledonous wood, fragments of bark and leaves, and some rather poorly preserved seeds, none of which can be identified definitely. It is possible, of course, that other nodules may be obtainable which, though of unpromising appearance, may contain recognizable petrified plant-remains.

The English roof-nodules are found in the beds immediately above coal-seams, while the Japanese nodules occur at least 100 ft. below the seams in their neighbourhood; but the association with coal-seams is probably more or less accidental, and the floras of the coal and of the nodules are not necessarily identical. They might, indeed, as Dr. Stopes believes is the case with the roof-nodules, belong to different plant associations, a fact which must be borne in mind when questions of correlation arise.

The recognizable plants from Kaipara are few in number. As in the Japanese nodules, and as in Upper Cretaceous floras generally, there is a mixture of ferns, gymnosperms and dicotyledons, but the material is insufficient for comparison with any other fossil flora. In the case of New Zealand no Upper Cretaceous flora has yet been adequately described, for the early work of Hector and Ettingshausen consists largely of *nomina nuda*, and Arber's monograph extended only to the Lower Cretaceous.

The following plants are recorded here: Ferns—*Taeniopteris batleyensis* n. sp., *Sphenopteris* sp. Gymnosperms—*Araucarites marshalli* n. sp., *Dadoxylon kaiparaense* n. sp., *Carpolithus zeelandica* n. sp., ? *Dammarites* sp. Dicotyledons—*Phyllites* sp., dicotyledonous wood.

Descriptions of Specimens.

Taeniopteris batleyensis n. sp. (Figs. 1, 2.)

Frond with the habit and venation of *Taeniopteris*, with secondary veins at right angles to midrib, but having circular sori with few sporangia between lateral veins, forming a row on each side of and close to midrib.

Dimensions: Maximum breadth, 1 cm.; length (incomplete), 5 cm.; diameter of sori, 1 mm. or slightly less.

Locality: Batley. One specimen only, with portion of counterpart.

The reference of this fertile frond to the form-genus *Taeniopteris* is purely provisional. The sporangial characters are not very well shown, and though the fern does not agree closely with any known genus of ferns, Recent or fossil, it seems inadvisable at present to create a new genus for

its reception, and additional material may throw further light on its affinities.

The midrib is stout and is partly petrified; the vascular bundle is apparently U-shaped in section, but the details are not clear. The secondary veins are at right angles, or nearly so, to the midrib, usually forking almost immediately, but sometimes running half-way to the margin before forking. In one case one of the branches can be seen to fork again. The sori are always close to the midrib and between the secondary veins. They are round papillae with a depression in the centre, and sometimes seem to contain 5 to 10 sporangia. The structure of the sori and sporangia cannot, however, be made out clearly, and it is impossible to see any trace of an annulus or of an indusium. In general appearance the sori resemble those of *Laccopteris*, which, however, are not situated definitely between the secondary veins, while the venation is distinctly reticulate. The genus *Nathorstia* is almost identical with *Laccopteris* in its vegetative characters, but the sporangia form a synangium, and *Nathorstia* can be recognized only in extremely-well-preserved material. In any case, the venation characters preclude a reference of our fossil to either of these genera, and it may further be noted that neither of them is known later than the Cenomanian.

Among Recent ferns the same type of venation occurs in *Oleandra*, but here the sori, which have a reniform indusium and numerous small sporangia, are situated immediately on the lateral veins, and usually at a short distance from the midrib. The genus is not known fossil, though sterile taeniopterid fronds have occasionally been referred to it on entirely inadequate grounds. Dawson described an inconclusive sterile fragment from Upper Cretaceous beds of Canada as *Pteris* (*Oleandra*) *glossopteroides*, but fossil fronds of the *Taeniopteris* type are mostly found in Jurassic and Lower Cretaceous beds. Some of these are now known to be cycadean, though the provisional generic name doubtless also includes some ferns. Several members of the Marattiales with a similar venation have been found fossil in a fertile condition, but the Kaipara fern does not agreé with any of them in soral characters, nor with any of the living ferns of the taeniopterid type with which I am acquainted.

Fern-petiole (fig. 3).—In the hollow pith of the araucarian wood described below a fairly-well-preserved fern-petiole is seen in transverse section. The C- or U-shaped vascular bundle, with the incurved xylem strand, is so characteristic of ferns in general that without further evidence reference even to a family is difficult. Its occurrence is of interest as showing the possibilities of the material, and it seems quite probable that it belongs to the same species as *Taeniopteris batleyensis*.

Sphenopteris sp. (Fig. 4.)

Locality: Bull's Point.

The only specimen is a small fragment of a fern-frond about 3 cm. long. The pinnules are narrow, cuneate-lanceolate, alternate, decurrent and uninerved, with an entire margin. It is difficult to place such a sterile fragment in its exact systematic position. Similar fronds occur frequently in Mesozoic rocks, and have often been referred to the Cyatheaceae, and especially to the genus *Thyrsopteris*, on insufficient evidence. Others of a similar type have been named *Asplenium* or *Asplenites*, and the present specimen also resembles some species of *Onychiopsis*, which is a widespread Lower Cretaceous genus. It does not seem possible to identify the fragment with any degree of accuracy, and it is therefore referred to simply as *Sphenopteris* sp.

Araucarites marshalli n. sp. (Figs. 5–8.)

Leaves thickly set on axis (usually occurring isolated), coriaceous, ovate or lanceolate, subacute, sessile with unguiculate base, finely striate longitudinally with numerous rows of stomatal pits. Internal structure: Numerous bundles with well-developed centrifugal wood radially arranged, centripetal wood (transfusion tracheides) present but not clearly preserved, resin-canals frequently but not always associated with bundles, numerous strands of hypodermal fibres, thick-walled idioblasts scattered through mesophyll.

The commonest fossils in the collection are leaves which I believe to belong very probably to the genus *Araucaria*, though, as there is always some uncertainty about detached organs, the usual termination *ites* is employed. They are referred to a new species, which I have much pleasure in naming after Dr. P. Marshall. Among Recent species there is considerable resemblance to the section *Colymbea*, and *Araucaria brasiliensis* in particular shows the rows of stomatal pits clearly, though they are not so distinct and well-marked a feature as in the fossil. This is a character which is not present in living specimens of *Agathis* as far as I have observed in herbarium specimens. Stomata were apparently present on both surfaces, but in the sections examined their structure was not preserved. Though the detached leaves from Kaipara exhibit considerable variation in size and shape, it seems probable that they all belong to the same species, in view of the similar variation among living araucarians.

Among comparable fossil species the nearest is *Araucarites macrophylla* (Bozzi 1892, p. 375, pl. 16, figs. 1, 2) from the Lower Senonian of Italy, which externally is very similar indeed, though Bozzi's species showed no internal structure, and he does not mention the rows of stomata. Another similar type is *Araucarites ovatus* Hollick (1898, p. 128, pl. xii, figs. 3*a*, 4) from the Magothy Formation (Cenomanian), in which, however, the leaves are acuminate, while in *Araucarites hatcheri* Wieland (1910, p. 80, pl. 1, fig. 2) they are narrower and even more acuminate. This species seems to show traces of the stomata, for the figures indicate dots on the surface, and the stomata are more clearly seen in rows in some specimens of *Araucarites bladenensis* (Berry, 1908, pl. 14, fig. 3).

Kraeusel (1922, p. 7) unites *A. bladensis* and *A. toucasi* Sap. with *A. crassifolia corda*, and also includes the specimen from Lesina figured by von Kerner as *Pachyphyllum rigidum*. He records the species from the Lower Senonian of Swalmen, Holland, and says that the American specimens differ solely in being slightly larger. All these forms, however, are much smaller and more acuminate than *Araucarites marshalli*.

The fossil araucarians of New Zealand have scarcely been adequately studied. The foliage described by Ettingshasuen (1887, p. 154) from Shag Point and Malvern Hills as *Araucaria haastii* seems to be similar to the present species, though the leaves are rather more lanceolate and acute and have a definite median rib. Ettingshausen also states that isolated leaves are not found. The specimens figured by Hector (1886) are without descriptions and are too poorly drawn for exact comparison, but they do not seem to be identical with our fossil. An examination of the originals, if available, might show an agreement between *Araucarites carinaria* (Hector, 1886, fig. 24*a*, No. 13: the name is misspelt) and *Araucaria haastii*, &c. Tertiary araucarians evidently occur in New Zealand, as in Australia, but it is usually very difficult to say whether they should be referred to *Agathis* or to *Araucaria*. Among similar Australian species we may note *Araucarites imbricatiformis* (Johnston) from the leaf-beds of Macquarie Harbour, Tasmania (Johnston, 1888, pl. 36, fig. 1, p. 294).

Some account of the internal structure has been included in the diagnosis, though the anatomical characters are not in general specific. Attempts to distinguish living species of *Araucaria* by their anatomy have not been very successful, and have been criticized by Seward and Ford (1906). On the whole, the anatomy of the present specimen resembles that of *Araucaria* rather more than that of *Agathis*, but the extent of the transfusion-tissue is not clear. In both *Agathis* and *Araucaria* sec. *Colymbea* the resin-canals alternate with the veins, whereas in the fossil they are usually below them, but also occur above or in the mesophyll more or less between the veins. Seward and Ford state that the canals are below each vein in *Araucaria rulei*, which is the flattest-leaved of the *Eutacta* group. The preservation of the fossil is scarcely good enough, however, for detailed comparison with living species.

? Dammarites sp. (Fig. 9.) Batley.

A portion of a leaf 2 cm. long and 1·5 cm. wide, with parallel venation, is obviously distinct from *Araucarites marshalli*. The veins, about 1 mm. apart, are more prominent, and occasionally bifurcate; there are no signs of stomatal pits, and the texture seems to be thinner. The leaf resembles some living species of *Agathis*, such as *Agathis vitiensis*, and some leaves of *Podocarpus* sec. *Nageia* are also rather similar. It is recorded here as evidence of another genus of plants, probably gymnospermous, in the Cretaceous rocks of Kaipara.

Dadoxylon kaiparaense n. sp. (Figs. 11–13.)

Annual rings of araucarian type, fairly well marked in places: bordered pits on radial walls in one or two (rarely three) rows in contact and sometimes slightly compressed; no pits on tangential walls; resin parenchyma absent; tracheids bordering rays sometimes containing resin, which is occasionally seen as "spools" in longitudinal section; medullary rays 1–8 cells high (usually 2 or 3), 1–10 pits in the field, and no abietinean pitting.

Locality: Bull's Point.

The above description is based on a stem 4 cm. in diameter, the centre of which is filled with the sandstone matrix containing the fern-petiole described above. A second (smaller) specimen, not so well preserved, doubtless belongs to the same species, the only observed difference being in the slightly greater height of the rays (up to 14 cells), which are sometimes biseriate.

I follow Professor Seward in referring fossil araucarian wood to *Dadoxylon*, though the present specimens, like many others of Upper Cretaceous and Tertiary age, closely resemble the wood of Recent members of the family. In fact, it seems to me quite probable that this is the wood of a species of *Araucaria* itself, and that it bore the foliage described above as *Araucarites marshalli*. There is, however, no evidence of connection, and it is unfortunate that the fragments of axis with leaves attached were not sufficiently well preserved to show the pitting. It must further be remembered that the wood of *Araucaria* and *Agathis* is extremely similar, and, indeed, indistinguishable in the fossil state.

The best-preserved fossil araucarian wood from New Zealand is *Dadoxylon* (*Araucarioxylon*) *novae-zeelandiae* (Stopes), from the Mid-Cretaceous (?) of Amuri Bluff. It differs from the present species in having better-marked annual rings, slightly larger tracheids, and a much greater development of resin in tracheids adjoining the rays (Stopes, 1914). The slight differences in the number of pits in the field and the height of the rays are probably unimportant. *Dadoxylon ettingshauseni* (Stopes) is poorly

preserved, but has larger tracheids and separated bordered pits. The wood from Amuri Bluff referred by Ettingshausen (1887, p. 156) to *Dammara oweni* is inadequately described and figured, but the drawing of the radial section (pl. 6, fig. 14) suggests that abietinean pitting of the ray-cells was present, and it seems quite probable that this wood may belong to *Protocedroxylon hectori* (Stopes). There is therefore no fossil araucarian wood from New Zealand closely resembling that from Kaipara, and it is consequently described as a new species.

Carpolithus zeelandica n. sp. (Fig. 10.)

Seed oval, winged, 8 mm. × 5 mm.; nucule 5 mm. × 3·5 mm. Wing or margin slightly contracted at base, broadly obtuse at apex. Nucule with median rib.

Locality: Bull's Point. One specimen, with counterpart; also one isolated nucule, probably of the same species.

Among the many figures of Cretaceous species of *Carpolithus* which I have examined there is none closely resembling the present species, though winged seeds of a somewhat similar type have been recorded from earlier Mesozoic rocks in various parts of the world. It is difficult to be certain of the true nature of the apparent wing, which might be the impression of a sarcotesta, and it is impossible to express any opinion as to the affinites of this seed except that it is probably gymnospermous.

Dicotyledonous Wood.—In addition to the fragments in the nodule mentioned above, a small stem from Bull's Point, about 1 cm. in diameter, was sectioned, but the preservation was too poor for description or identification.

Phyllites sp.

There are several small fragments of dicotyledonous leaves; one of these occurs on the same block as the *Sphenopteris*. A collodion imprint was obtained which showed only the upper surface of a leaf without stomata. A larger fragment, from Bull's Point, shows venation details very clearly, but in the absence of base, apex, and margin it is impossible to attempt identification. Collodion imprints again showed no stomatal details.

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The Upper Cretaceous Ammonites of New Zealand.

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hector and Hutton Medallist, N.Z. Institute.

[*Read before the Wellington Philosophical Society, 7th October, 1924; received by Editor, 13th October, 1924; issued separately, 13th March 1926.*]

Plates 19–47.

CONTENTS.

DISCOVERY.

IN the year 1917 (49, p. 443) a brief statement was made of the occurrence of ammonites at Batley, on the Otamatea arm of the Kaipara Harbour, North Auckland Peninsula. Since that time several visits have been made to Batley, and to Bull's Point, a neighbouring locality on the Arapaoa arm of the harbour where similar beds occur and where many of the same species of fossils are found. The first party, in 1916, included Mr. J. A. Bartrum, Lecturer on Geology at the Auckland University College, and Mr. R. Browne. In 1919 and in 1922 further visits were made to Bull's Point, and in 1923 collections were again made at Bull's Point and at Batley. In addition, a few specimens were found by Professor Benson and Mr. Bartrum in 1920, and by Mr. Ferrar, of the Geological Survey, in 1923.

The result of all these collections has been the revealing of a fairly extensive fauna. It consists of specimens of several species belonging to all the important groups of mollusca, a few brachiopods, and a variety of fish-scales. There are also the remains of five species of plants. Probably the most interesting portion of the collection is that consisting of ammonites. Up to the present time very few species of ammonites have been recorded from the Cretaceous of New Zealand, and, with the exception of three species recorded in the previous paper on Batley, all have been collected in the South Island. They were first mentioned by Hector, and have been classified in papers written by Woods (57, p. 34), Trechmann (56, p. 338), and Spath (54). The species hitherto recorded are as follows: *Madrasites haumuriensis* Hector, *Madrasites* sp., *Gaudryceras jukesi* Sharpe (Whiteaves), *Gaudryceras sacya* Forbes, *Grossouvrites gemmatus* Huppe, *Baculites* cf. *vagina* Forbes, *Kossmaticeras zelandicum* Marshall, *Kossmaticeras tenuicostatum* Marshall, *Madrasites bhavani* Forbes, *Lytoceras* sp.

The latest reference to the Upper Cretaceous ammonites of New Zealand is that of Spath (53, p. 299):—

"The writer has lately recognized the presence in the Upper Senonian of New Zealand of *Kossmaticeras* (*Madrasites*) *bhavani* Stol. sp., and *K.* (*M.*) *cumshewaense* (? Whiteaves) Kilian and Reboul[1], as well as of *K.* (*Gunnarites*) aff. *bhavaniforme* Kilian and Reboul, *K.* (*Grossouvrites*) *gemmatum* Huppe sp., and of *Pseudophyllites* (*Tetragonites*) sp. juv.[2] "

"Footnote (1): Possibly close to the incompletely known *K.* (*Madrasites*) *mcKayi* Hector sp. (*Catal. N.Z. Court*, 1886, p. 57, text-fig. 19A, No. 4) (misspelt *maeCoyi* in *Haug. Traite*, 2, p. 1345), that Steinmann (*loc. cit.*, 1895, p. 28) considered to belong probably to the group of *K.* (*M.*) *aemilianum* Stol. sp."

"Footnote (2): In collections kindly sent by Mr. Henry Woods, F.R.S., and by Dr. Trechmann (see *Geol. Mag.*, n.s., dec. 6, vol. 4, 1917, p. 338)."

In the following pages sixty species are recorded, and all are described. This is done even when the specimens are identified as species already described from other countries, a practice adopted for the following reasons: (1) The literature in which the descriptions of these Upper Cretaceous ammonites have been published is very scattered and most difficult to obtain in New Zealand; (2) the distinction of the different species is carried to such a degree of refinement that the identifications made in this paper may be questioned by workers elsewhere, and in such cases it is well to have a description and a figure to which reference can be made; (3) the great distances between some of the countries where a few of the species have been recorded, and the absence of actual specimens for comparison, make identification difficult and even hazardous.

GEOLOGICAL OCCURRENCE.

The formation in which the fossils occur is an unctuous mudstone which becomes arenaceous in places and even conglomeratic, and it contains many concretions varying in size from 5 ft. in diameter downwards. The great majority of the fossils have been found in the concretions, which are sometimes composed of spherical aggregates of calcite crystals—"pseudopisolitic"—and often show on the exterior an extremely well developed layer of cone-in-cone structure. The development of these structures has sometimes obscured certain features of the fossils, and in particular the suture-lines are occasionally hard to follow. The matrix of the specimens is also extremely hard, and the fossils are often fractured while they are being extracted. On the other hand, much of the shell matter remains, and in the great majority of instances the suture-lines are remarkably clear and easy to follow.

The thickness of the formation in which the fossils are found is difficult to estimate. On the foreshore of the harbour where the strata occur the whole outcrop is covered with debris, for the unctuous nature of the rock allows of earth-sliding to an unusual degree, and it is rarely that any portion of the cliff-face can be seen. Above the immediate shore-line the whole surface of the hill is covered with vegetation, which effectually conceals the rock from observation. Here and there, where a small exposure is visible, the strata stand at a high angle. The average direction of the strike at Bull's Point is 285°, and at Batley 295°. In both localities the ammonite-bearing strata are succeeded by a fine-grained chalky limestone, composed for the most part of tests of *Globigerina*—the so-called "hydraulic limestone" (49, p. 440).

At Bull's Point there are occasional nodules of barite, and frequently boulders of the lower part of the hydraulic limestone are thickly impregnated with black manganese oxides. Concretions of pyrite, also, are of frequent occurrence; and in the interior of many of the concretionary boulders of the ammonite beds, which are often septarian in nature, it is not unusual to find well-developed crystals of calcite. It is often found that a portion of the hydraulic limestone is siliceous and even flinty. This is probably due to the presence of siliceous organisms such as diatoms, radiolaria, and sponge-spicules, the occurrence of which has been reported by Marshall in similar material obtained from neighbouring localities (49, p. 434). Manganese dioxide, barite, and pyrite are found in far greater abundance on the northern shore of the Pahi arm, near Mr. Blackwell's house. Mr. Blackwell was good enough to point this out. A similar association is found on the eastern shore of the inlet behind the Batley Peninsula. In all these instances the occurrence of the minerals seems to be in the material near the base of the hydraulic limestone.

At Whangaroa the strata that contain the fossils are very similar to those at Bull's Point; but they appear to lie directly beneath the Wairakau breccia of Bell and Clarke (47, p. 65). No actual contact of the two formations could, however, be observed. The geology of this district was first described by McKay in 1892, but he did not collect any Upper Cretaceous fossils on the Whangaroa, except specimens of the genus *Inoceramus* (18, p. 68). He does, however, record ammonites as occurring in concretions in the south branch of the Kaeo River, In 1875 Mr. R. Bell, who then lived on the north side of the Whangaroa Harbour, near Totara North, sent several specimens to the Auckland Museum. Among these is a poor specimen of *Gaudryceras kayei* Forbes, and an excellent specimen of *Tainuia multispinosa* n. sp., which has also been found at Bull's Point. There is also a specimen of *Phylloceras minimum* n. sp., numbers of which have been found in the Kaipara localities. Bell's specimens probably came from the south side of the harbour, for in his letter to the curator of the Museum he says that the specimens in "sandstone" came from the south side of the river. Though "sandstone" is not a correct term to apply to the matrix of the specimens, it is certainly more nearly correct than "shale"—the only other material mentioned by Bell. The matrix is very similar to that of the fossils since obtained on the south side of the harbour. On both sides of the harbour concretions have been much used for roadmaking, and at the present time few of them can be found except at Nedler's Point, near the head of Waitapu Bay, about 200 yards distant from the road.

Clarke in 1909 (47, p. 56) stated that the concretions at Nedler's Point contained numbers of fossils, though the specimens he collected were few

and in bad preservation. However, he definitely stated that ammonites could be found in the concretions at Nedler's Point and made it possible for subsequent collectors to obtain specimens easily. In April, 1923, a considerable number of fossils, which are described in the following pages, were found in the concretions at Nedler's. Their nature and geographical occurrence will be discussed after the species in the whole collections have been recorded and described. The outcrop of rock is small, and perhaps rather less unctuous than at the Kaipara localities, but otherwise there is little difference. There are not many concretions to be found, but a larger proportion of them is fossiliferous than at Batley and Bull's Point. On the north side of the harbour there are now no concretions remaining, and no ammonites were found by me, but a few large masses of limestone contained numerous fragments of *Inoceramus* and specimens of another large species of pelecypod.

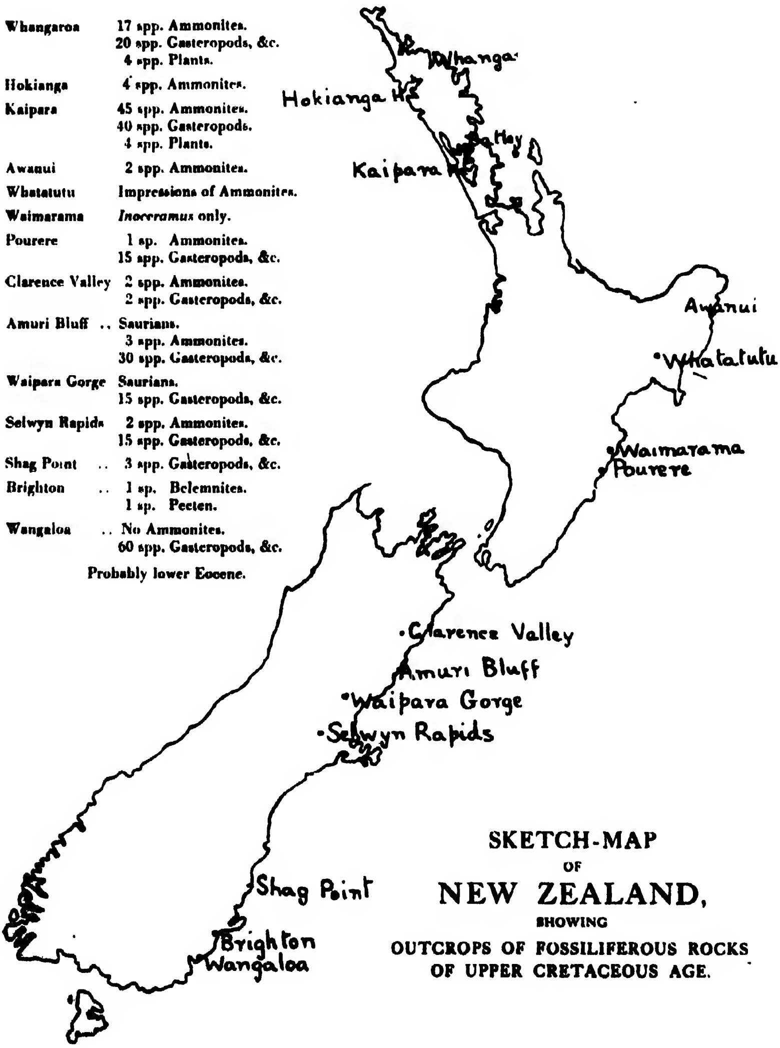
In addition to the localities mentioned above, Mr. Ferrar, of the Geological Survey, has recently collected specimens of ammonites at Te Opu, which is quite close to Bull's Point. None of the species found there are different from those found at the latter locality. He also found a few species at Matakohe, about six miles to the north-west. There are also a number of specimens of *Vertebrites murdochi* in the Auckland Museum. These were obtained at Hokianga, though the exact locality is not recorded. In the same place there is also a good specimen of *Baculites rectus* and one of *Gaudryceras semileve*, said to have been found at Morant's Island, in the Kawhia Harbour. This is probably an error, for Morant's Island is composed entirely of a glauconitic limestone, containing a great number of Tertiary fossils, whereas the matrix of the ammonite specimens is a shale. It is possible that "Kawhia" is a *lapsus calami* for "Kaipara."

In the collection of the Geological Survey there are two ammonites collected by McKay at Awanui, near the East Cape; but subsequent collectors have failed to find any additional specimens. The two species are similar to some found at Bull's Point. One is close to *Zelandites kaiparaensis*, and the other is probably *Schluteria rarawa*. Ongley has recently found a small ammonite at the Pourere Beach, about forty miles south of Napier, but unfortunately it is not in a condition that admits of identification. He has also found a few impressions of ammonites near Whatatutu, inland from Gisborne.

All these localities are shown on the accompanying map, and it is evident that we now have definite information of the occurrence of a considerable extent of Upper Cretaceous strata in which ammonites have been found. There is reason to hope that a large fauna will ultimately be discovered. A map of the Kaipara will be found in 49, p. 435, and a map of Whangaroa in 47, map 3.

I wish to record my grateful thanks to the following institutions and friends: To the authorities of the South Kensington Natural History Museum, for giving me the use of a room and for allowing me to use their vast collections for comparisons; to the authorities of Victoria University College, Wellington, for giving me the use of a room in which to do my research; to the New Zealand Institute, for allowing me a grant of £40 from the Hutton Fund, and one of £50 from the Research Grant, to defray some of the expenses incurred. The following gentlemen have materially assisted me in collecting material: Mr. J. A. Bartrum, Lecturer on Geology, Auckland University College; Professor Cotton, Victoria College; both

of these gentlemen kindly allowed me to use the resources of their laboratories. Mr. R. Brown and Mr. W. Blackwell also assisted me most materially in making the collections, and R. Marshall also added important specimens. Dr. L. Spath and Professor W. Kilian kindly examined many



Whangaroa	17 spp. Ammonites. 20 spp. Gasteropods, &c. 4 spp. Plants.
Hokianga	4 spp. Ammonites.
Kaipara	45 spp. Ammonites. 40 spp. Gasteropods. 4 spp. Plants.
Awanui	2 spp. Ammonites.
Whatatutu	Impressions of Ammonites.
Waimarama	*Inoceramus* only.
Pourere	1 sp. Ammonites. 15 spp. Gasteropods, &c.
Clarence Valley	2 spp. Ammonites. 2 spp. Gasteropods, &c.
Amuri Bluff ..	Saurians. 3 spp. Ammonites. 30 spp. Gasteropods, &c.
Waipara Gorge	Saurians. 15 spp. Gasteropods, &c.
Selwyn Rapids	2 spp. Ammonites. 15 spp. Gasteropods, &c.
Shag Point ..	3 spp. Gasteropods, &c.
Brighton ..	1 sp. Belemnites. 1 sp. Pecten.
Wangaloa ..	No Ammonites. 60 spp. Gasteropods, &c. Probably lower Eocene.

SKETCH-MAP
OF
NEW ZEALAND,
SHOWING
OUTCROPS OF FOSSILIFEROUS ROCKS
OF UPPER CRETACEOUS AGE.

of my specimens and gave me most valuable advice. Dr. J. Marwick kindly copied drawings of the cross-sections for publication. The Australian Museum generously granted me a long loan of Kossmat's work; this is out of print and there are no copies in New Zealand.

DESCRIPTIONS OF SPECIES.

Dimensions.—In all cases the first column under each species gives the actual measurement; the second column gives the proportional measurement, assuming the diameter to be 100 mm.

All dimensions are given in millimetres, and all types, except four—*Maorites tenuicostatus*, *Gunnarites zelandicus*, *Oxybeloceras* sp., *Tainuia aucklandica*—are at present in my collection.

PHYLLOCERAS Suess.

Phylloceras nera Forbes. (Plate 19, fig. 4; Plate 26, figs. 1, 2.)

Compare—

1845. *Phylloceras nera* Forbes (1. p. 106, pl. 8, fig. 7).
1885. *Phylloceras velledae* Mich., in Stol. (11, p. 116).
1895. *Phylloceras nera* Forbes, in Koss. (28, p. 109, Taf. 16, fig. 2 *a–d*).
1906. *Phylloceras* sp. Woods (57, p. 331, pl. 41, fig. 4).
1907. *Phylloceras nera* Forbes, in Pauleke (42A, p. 3, Taf. 14, fig. 5 *a, b, c*).
1921. *Phylloceras nera* Forbes, in Spath (59, p. 40).
1921. *Phylloceras woodsi* van Hoepen (52. p. 3. pl. 2. figs. 1–6. text-fig. 1).
1922. *Phylloceras woodsi* van Hoepen, in Spath (54, p. 117).

Dimensions:—	A.		B.		C.		D.		E.	
Diameter	42	100	13	100	24·5	100	46	100	20	100
Height of last whorl ..	23	54	8	61	14·6	60	28	61	12	60
Width of last whorl	11	26	4	30	7·4	30	13·2	29	6	30
Umbilicus	6	12	2·3	17	2·0	8	2·8	6	1·5	8

A and B. *Phylloceras nera* Forbes, Bull's Point, Kaipara Harbour, N.Z.; C and D, *Phylloceras woodsi* van Hoepen (52, p. 4); E. *Phylloceras nera* Forbes, in Koss. (28, p. 160, Taf. 16. fig. 2. *a–d*).

Shell discoidal, slightly umbilicated. Whorls strongly involute, high and narrow with greatest thickness about one-third of height measured from umbilicus. Umbilical wall steep and passing gradually into flank: curve gradually increases, and finally periphery is almost a circular arc. Umbilicus cannot be properly cleared but is evidently extremely narrow, and a very small portion of any of inner whorls is exposed.

Ornamentation: Numerous thin rounded ribs, twenty in number, on a length of 10 mm. of periphery when height of whorl is 12 mm. They are hardly visible near umbilicus, and have a slight bend forward, but soon straighten up and pass over periphery without any change. On lower part of flank are six conspicuous folds in a half-revolution. These are strongly marked at umbilicus and curve forward in the same way as ribs, but soon weaken, and disappear completely half-way up flank.

Suture-line does not materially differ from that of *P. nera* figured by Kossmat; but in the largest specimen only five saddles can be distinguished, though in a smaller specimen, in which the details are less clear, eight saddles can be distinguished. The excellent preservation of the large specimen allows all the details to be seen where the whorl height is ·19 mm. Owing to the shortness of the external lobe and the large development of the external branch of the first lateral lobe, the overlapping and inclined nature of the first lateral saddle is well shown. This feature was recorded by van Hoepen in the suture-line of *Phylloceras woodsi*.

The umbilicus of this species is wider than that of *P. nera* from Patagonia and of *P. woodsi* of Pondoland, and in addition there are twice as many folds as in the last species. The umbilicus is smaller than in *P. decipiens* Koss. This species differs from *P. velledae* in its more compressed form, and the folds disappear more quickly than in *P. surya*. The suture-line, however, is more like that of *P. surya* than that of *P. nera*.

Four specimens have been found, but all are incomplete. It has been found at Bull's Point, Batley, and at Whangaroa.

Phylloceras radiatum n. sp. (Plate 19, fig. 7; Plate 26, figs. 3, 4.)

Compare—

1835. *Ammonites velledae* Mich., *Mag. de Zool.*, pl. 35.
1840. *Ammonites velledae* Mich., in d'Orb., *Terr. Cret. T. I. Ceph.* pl. 82.
1857. *Ammonites (Scaphites) ramosus* Meek, *Trans. Alb. Inst.*, vol. 4, p. 45.
1860. *Ammonites velledae* Mich., in Pictet et Camp., *Terr. Cret. Ste Croix*, vol. 1, p. 268, pl. 36, fig. 8.
1864. *Ammonites ramosus* Meek, in Gabb, *Geol. Surv. Canada. Pal.*, vol. 1, p. 65, pl. 11, fig. 4; pl. 12, fig. 12.
1865. *Ammonites velledae* Mich., in Stol. (11, p. 116, pl. 59, figs. 1, 4).
1865. *Ammonites ramosus* Meek, in Gabb (3, p. 65, pl. 11, fig. 4: pl. 12, fig. 12).
1873. *Ammonites velledae* Mich., in Schmidt, Kreidepetrefacten von Sachalin (*Mem. Acad. St. Petersburg*), p. 10, Taf. 1, figs. 3, 4.
1876. *Phylloceras ramosum* Meek, in White, *Bull. U.S. Geol. Surv.*, vol. 4, p. 372, pl. 5, fig. 1.
1879. *Ammonites velledae* Mich., in Whiteaves (8, p. 103).
1890. *Phylloceras velledae*, Mich., in Yokoyama (17, p. 177, Taf. 19, fig. 1).
1895. *Phylloceras ramosum* Meek, in Steinmann (26, p. 80, Taf. 5, fig. 4 *a*, *b*).
1902. *Phylloceras ramosum* Meek, in Anderson (33, p. 34).
1906. *Phylloceras velledae* Mich., in Boule, Lemoine, and Thevenin, *Ceph. Diego Suarez*, p. 7, pl. 1, figs. 6, 10, 11.
1909. *Phylloceras (Schluteria) ramosum* Meek, in Kilian and Reboul (46, p. 9, pl. 1, fig. 3).
1920. *Phylloceras umzambiense* van Hoepen (51, p. 142, pl. 24, figs. 1, 2, 3).
1922. *Phylloceras umzambiense* van Hoepen, in Spath (54, p. 117).

Dimensions:—

	A.		B.		C.		D.		E.	
Diameter	43	100	32	100	150	100	44	100	38	100
Height of last whorl ..	25	58		56		57	27	62	16	42
Width of last whorl	18	42		26		58	17	40	13	34
Umbilicus	2	5		9		6	2	5		

A. *Phylloceras radiatum* n. sp., Kaipara Harbour, N.Z.; B, *Phylloceras surya* Forbes, in Stol. (11, p. 115, pl. 58, fig. 5); C, *Phylloceras velledae* Mich., in Stol. (11, p. 116, pl. 59, figs. 1–4); D, *Phylloceras umzambiense* van Hoepen (51, p. 142); E, *Phylloceras velledae* Mich., in Yokoyama (17, p. 177, pl. 19, fig. 1 *a*, *b*).

The dimensions show that this species is distinct, though it approaches D.

Shell discoidal, strongly involute, and higher than wide. Greatest thickness rather nearer to umbilicus than to external border. Flank has a uniform curve from umbilicus almost to median line. Umbilicus deep and extremely narrow.

Ornamentation: Numerous narrow ribs steeper in front than behind. They commence as extremely fine lines at bottom of umbilicus, and gradually increase in size towards external margin, when at a height of 12 mm. there are eighteen ribs on a length of 10 mm. of periphery. Within umbilicus they are curved strongly backwards, but on leaving it curve a little forward, but straighten half-way between umbilicus and periphery, which they cross without any curve. As far as can be seen, there are no interstitial ribs. A series of wide folds, twelve in a half-whorl, extend from umbilicus across periphery, but they lose somewhat in height as they approach periphery. There are four or five ribs on each of the folds, which do not curve like the ribs, but are strictly radial in their direction. The folds seem to be more pronounced on surface of body-chamber, but the specimens are too imperfect to be certain of this.

The dimensions given above show that the species is much wider than *Phylloceras surya* and a good deal narrower than *P. velledae*. In dimensions and form of whorl it approaches more closely to *P. umzambiense* than to any other species of which details are available. Umbilical wall not so steep as that of *P. ramosum* Meek in Steinmann, and the whorl appears rather wider than that of *P. ramosum* Meek in Kilian and Reboul.

Suture-line a good deal less divided than in *P. ramosum* Meek in Steinmann, and less than that species in Kilian and Reboul as far as can be seen from their figure. It is, however, of a typical Phylloceratid type, rather more complex than that of *P. velledae*, and decidedly more so than the suture-line of *Phylloceras ellipticum* Koss., a species that it closely resembles in the details of ornamentation. *Phylloceras radiatum* clearly belongs to the *velledae* group of the genus, which persisted through all Upper Cretaceous times. The marked radial folding, combined with the form of the whorl and the nature of the costation, seem to me to distinguish it from all others. In the costation it comes nearer to *P. ellipticum* Kossmat; in the form of the whorl and the folding the closest species is *P. umzambiense*; while in the development of the suture-line it lies between *P. ramosum* and *P. velledae*.

The internal portion of the suture shows only three saddles. The only figures available for comparison are those given in Zittel's *Handbuch*, vol. 2, p. 436. Here the line of a Dogger species is shown, but it has six saddles. It is interesting to note that *Sowerbyceras* has three saddles.

One good specimen and two fragments from Bull's Point, and one fragment from Whangaroa.

Phylloceras forbesianum d'Orbigny. (Plate 19, fig. 6; Plate 27, figs. 3, 4.)

Compare --

1845. *Ammonites rouyanus* d'Orb., in Forbes, *Geol. Soc. Lond.*, ser. 2, vol. 7. pl. 8, fig. 6, p. 108.
1850. *Ammonites forbesianus* d'Orb., *Prodrome*, vol. 2, p. 13.
1865. *Ammonites rouyanus* d'Orb., in Stol. (11, p. 117, pl. 59, figs. 5–7).
1890. *Phylloceras ezoense* Yokoyama (17, p. 178, pl. 19, fig. 1 *a–c*).
1895. *Phylloceras forbesianum* d'Orb. and *P. whiteavesi* Koss., in Kossmat (28, p. 109, pl. 15, fig. 1; also p. [189]).

Dimensions :—

	A.		B.		C.		D.		E.	
Diameter	25	100	18	100	13	100	14·5	100	28	100
Height of last whorl ..	15	60	12	66	8·2	63	8·5	58	18	64
Width of last whorl ..	15	60	12	66	8·2	63	9	62	17	61
Umbilicus	1	04	..		..					

A, *Phylloceras forbesianum* d'Orb., in Koss. (28, p. 109, pl. 15, fig. 1 *a–d*); B, C, D, E, *Phylloceras forbesianum*, Bull's Point, Kaipara Harbour, N.Z.

Whorls rapidly increasing and extremely involute, so that umbilicus is practically obscured. Height and width almost equal, and cross-section almost circular. This is the same as in dimensions of *P. forbesianum* given by Kossmat, though the figure shows a far greater height than width. The whorl rises at first steeply from umbilicus, but curves uniformly in circular arc and has its widest part about half-way between umbilicus and periphery.

Ornamentation: Comparatively little of the material of the shell remains, but this shows a fine striation beginning on umbilical wall, at first bending backward strongly, but at half-way along flank it is succeeded by a bend forward; thereafter the striae become straight and cross periphery without a bend. After every seventh or eighth rib is a decided groove, most noticeable near umbilicus but becoming obscure on periphery.

Suture-line very similar to that given by Kossmat for *Phylloceras forbesianum*, though it is rather more complex and there is a far greater number of saddles, of which as many as twelve can be distinguished. These, of course, are very small in umbilical region, and they are much higher than wide. The external lobe is unusually deep. The external saddle is

largest, and there is a uniform decrease in size as umbilicus is approached. This species differs from *P. forbesianum* in dimensions of whorl if Kossmat's figure is correct, though the measurements that he gives agree closely with those of this species. Suture-line of this species also is rather more developed than that of the Indian one. Yokoyama compares his species *P. ezoense* with *P. forbesianum*, but states rightly that the whorl is too high. His figure also suggests that the costation is too coarse.

Kossmat, in an appendix to his work on the Indian ammonites, separates the specimens which in the earlier part of his work he had classed together under *P. forbesianum* into two species, *P. forbesianum* and *P. whiteavesi*. Some of these specimens had come from the Utatur formation, of Cenomanian age, and others from the Valudayur beds, of Upper Senonian age. In the appendix he retains the former under the name of *P. forbesianum*, and establishes the species *P. whiteavesi* for the latter. The former species is somewhat more inflated and does not show the funnel form of the umbilicus so distinctly as the latter. In addition the saddles of the suture-line are larger, and the median saddle is simple and lancet-shaped, while in the two other occurrences (Valudayur beds of Pondicherry and the Nanaimo beds of Vancouver) it is strongly indented. He says that these are truly small distinctions, but they accord with different geological occurrences, so that great importance must be attached to them. He attaches great importance to the relation between the ultimate and penultimate whorls. In the specimens of *P. forbesianum* from the Utatur formation the relation in different specimens is 1 : 2·75, 1 : 2·5, 1 : 2·6, while in a specimen of *ezoense* which is similar to *P. whiteavesi* it is 1 : 3·2 (11, p. 124).

In this respect the New Zealand specimens are similar to *P. forbesianum*, for the relation is 1 : 2·5 and 1 : 2·25. In other words, the increase of the size of the whorls of the New Zealand species is less rapid than even that of the Utatur species. On the other hand, in the details of the suture-line there is a greater similarity to *P. whiteavesi*, for the median saddle is sharply indented and at the same time the saddles are relatively longer. It seems, then, that this species has some of the determining characters of each of the related Indian ones.

Several specimens, most of which come from Bull's Point, though others come from Batley and from Whangaroa.

Phylloceras minimum n. sp. (Plate 19, fig. 8; Plate 26, figs. 5, 6.)

Dimensions :—

	A.		B.	
Diameter	13	100	8·5	100
Height of last whorl ..	7·5	57	5	58
Width of last whorl ..	7	54	4·5	53
Umbilicus				

A, B, *Phylloceras minimum*, Kaipara Harbour, N.Z.

Shell small, highly involute, and, as dimensions show, height and width almost equal. Umbilicus obscured. There is a steep slope from umbilicus, and the greatest thickness is reached at a distance of about one-third of height from it, whence the curve is that of a circular arc over periphery. A series of fine hair-like striations commences at umbilicus, and at first are directed backwards; then they bend forwards and then straighten towards periphery, which they cross without any bend. They remain fine, but are much more distant on periphery.

The suture-line is highly developed when the size of the species is considered. The saddles are relatively long and well separated from one

another. There is also a large number of auxiliary saddles. In this species, again, the internal portion of the suture-line has three saddles only. The internal saddle, as before, has the curious form characteristic of the genus.

This species is very similar to the last, but the ornamentation is far less distinct, and the whorl is wider. The suture-line also is more developed.

A number of specimens of this small species from Bull's Point and from Batley.

Phylloceras bistriatum n. sp. (Plate 19, fig. 5; Plate 27, figs. 1, 2.)

Compare—

1865. *Ammonites subalpinus* d'Orb., in Stol. (11, p. 114, pl. 58, fig. 3).
1895. *Phylloceras ellipticum* Koss. (28, p. 107, pl. 15, fig. 2).
1890. *Phylloceras ezoense* Yokoyama (17, p. 19, pl. 2, fig. 178).
1921. *Phylloceras ezoense* Yabe (61, p. 54, pl. 8, fig. 2).

Dimensions:—

	A.		B.	
Diameter	43	100	25	100
Height of last whorl	27	63	15	60
Width of last whorl	22	51	15	60
Umbilicus	..		1	4

A. *Phylloceras bistriatum* n. sp., Bull's Point, Kaipara Harbour, N.Z.: B. *Phylloceras forbesianum* d'Orb., in Koss. (28, p. 109, Taf. 15, fig. 1).

A discoid highly involute form, with umbilicus reduced to smallest dimensions. Cross-section nearly circular, but there is a distinct angle at top of umbilical wall. The shell matter is poorly preserved, but it can be seen that interior whorls have an extremely fine, somewhat distant striation. On body-chamber there are in addition a number of large rounded ribs, which are narrow at umbilicus and gradually widen as they approach periphery, which they cross without change. The fine striations can be seen between and on the slopes of these large ribs.

Suture-line: Unfortunately only five of the saddles can be exposed. They are less finely divided than those of the other species, and the terminations are rounded and coarse. The secondary saddles in the lobes are but little divided.

So far as the suture-line is concerned, this species approaches most closely to the *improvisum-ellipticum* group in the Indian Lower Cretaceous fauna. It comes very close to *P. ezoense* Yokoyama (in Yabe, 1921).

A single specimen, in fair order, at Bull's Point.

Vertebrites n. gen.

It is considered necessary to establish this new genus because, though numerously represented by many specimens in splendid condition, it cannot be included in the genus *Gaudryceras* as emended by Kossmat (28, p. 113). The particular distinction is found in the internal portion of the suture-line, which shows six distinct saddles gradually decreasing in size from the antisiphonal line to the umbilicus. This condition is wholly different from that described by Kossmat as characteristic of *Gaudryceras*, which has a high single and narrow saddle in the internal portion of the suture-line. It may, of course, be maintained, as is suggested by Spath (53, p. 239), that such a development "is a result of the adaptation of a suture-line to wider sides." This, however, does not seem to be a sufficient explanation in this instance, for the various species of the closely related

genera *Tetragonites* and *Pseudophyllites*, in which the reduction of the sides is even more extreme than in the species of *Gaudryceras*, have an internal suture-line in which there are two well-separated saddles.

The species placed in this genus is clearly the New Zealand representative of the well-known and widely-distributed Indo-Pacific species *Gaudryceras kayei* Forbes. It seems, however, that the internal suture-line of that species has not yet been observed; and if, as seems probable, it should prove to be similar to that of *Vertebrites murdochi* it will have to be included in this new genus. It is not the suture-line alone that distinguishes these forms from the typical species of *Gaudryceras*: there is in addition the curious low and wide shape of the whorl, as well as the conspicuous difference in the ornamentation on the flanks as compared with that on the periphery.

The name *Vertebrites* is given to the genus because of the resemblance of a cross-section to that of a fish-vertebra.

Vertebrites murdochi n. sp. (Plate 20, figs. 9, 9*a*; Plate 30, figs. 1, 2; Plate 40, fig. 3.)

Compare—

1845. *Ammonites kayei* Forbes (1, p. 101, pl. 8, fig. 3).
1865. *Ammonites kayei* Forbes, in Stol. (2, p. 156, pl. 77, fig. 3).
1871. *Ammonites kayei* Forbes, in Griesbach, *Q.J.G.S.*, vol. 27, p. 63.
1879. *Ammonites jukesi* Sharpe, in Whiteaves (8, p. 111, pl. 13, figs. 3 *a, b, c*).
1893. *Gaudryceras planorbiforme* Bohm, in de Grossouvre (19, p. 231, pl. 27, fig. 2).
1895. *Lytoceras kayei* Forbes, in Steinmann (26, p. 86, pl. 5, fig. 5).
1895. *Lytoceras (Gaudryceras) kayei* Forbes, in Kossmat (28, pp. 124, 162, pl. 16, fig. 5; pl. 17, fig. 2).
1902. *Lytoceras (Gaudryceras) kayei* Forbes, in Anderson (33, p. 83).
1909. *Lytoceras (Gaudryceras) kayei* Forbes, in Kilian and Reboul (46, p. 12).

Dimensions:—

	A.		B.		C.		D.		E.		F.		G.	
Diameter ..	25	100	27	100	27	100	42	100	36	100	29	100	26	100
Height of last whorl	7	28	7	26	6·5	24	10·25	24	9	25	7·75	27	6·75	26
Width of last whorl	10·5	42	11	41	11	41	16	39	14	39	13	44	12·2	47
Umbilicus ..	14·5	58	14	53	15	55	25	60	21	58	16	55	14·8	57

	H.		J.		K.		L.		M.		N.		P.	
Diameter ..	29·8	100	30	100	31	100	28·8	100	30	100	26·2	100	10	100
Height of last whorl	7·0	24	7·4	25	7·2	23	7·2	24	6·9	23	5·9	23	2·2	22
Width of last whorl	11	37	11	37	13·2	43	12·6	43	13	43	11·8	45	5	50
Umbilicus ..	18	60	16	53	15·4	53	16·0	55	17	57	14·8	56	6·2	62

	Q.		R.		S.		T.		V.		W.		X.	
Diameter ..	22·5	100	58·5	100	12·6	100	30	100	57	100	46	100	24	100
Height of last whorl	6·5	29	18·5	32	3	24	8	27	19	33	15	33	8	33
Width of last whorl	9·5	33	18	31	5	40	10	33	18	32	15	33	9	37
Umbilicus ..	12·0	53	27·5	47	7	56	16	53	28	50	23	50	13	55

A, B, C, *Vertebrites murdochi*, Batley, Kaipara, N.Z.; D, E, F, G, H, J, K, L, M, P, *Vertebrites murdochi*, Whangaroa, N.Z.; N, *Vertebrites murdochi*, Hokianga, N.Z.; Q, *Ammonites kayei* Forbes, in Steinmann, *l.c.*; R, S, *Gaudryceras kayei* Forbes, in Koss., *l.c.*; T, V, W, X, *Gaudryceras kayei* Forbes: specimens in Kaye's collection in British Museum, Natural History Branch, South Kensington, London; measured by P. Marshall.

These dimensions clearly show that the New Zealand specimens from three localities belong to the same species, and they differ from the typical Indian specimens in having a distinctly lower and also wider whorl and a slightly wider umbilicus. It might appear as though the dimensions of S contradicted this statement; but small specimens are all wider, and S should be compared with P.

Shell discoidal, with an involution of about one-third. Whorls much wider than high, with a surface rising steeply from umbilicus and passing with a gradually decreasing curve to periphery, where it is much flattened. The deep umbilicus has a steep slope almost uniform except for upper part of each whorl, which breaks the regularity with rather sharp curve. Whorls do not increase rapidly, and seven can be counted when shell has a radius of 10 mm. Strong sharp wire-like ribs start at bottom of umbilicus and are at first radial, directed slightly backwards; almost at once they curve strongly forwards, but become almost radial again on upper part of flank at point where covered by succeeding whorl. A little below this an interstitial rib generally appears between each pair of wire ribs, and at this line each rib usually breaks up into three fine striations. Other striations also take their origin at this level, though the original rib often continues straight on, but with the dimensions of one of the striations only. These striations at once bend forward and cross periphery with a gentle broad forward curve. On body-chamber the coarse wire ribs become much less numerous and are irregularly spaced, but the fine striations maintain their number and appearance.

The external portion of the suture-line is similar to that shown by Stoliczka for *Gaudryceras kayei*; Kossmat does not give a drawing of it. Six saddles can be distinguished, the external by far the largest. Auxiliary saddles much inclined, and with auxiliary lobes form a deep umbilical lobe. External lobe a little deeper than first lateral lobe. Internal portion of suture-line at once distinguishes the genus. Instead of the single lengthened saddle which is found in *Gaudryceras*, six distinct saddles can be seen. Of these the first, which is close to the antisiphonal line, is the largest and is bifid, though the division is not deep. The next saddle is shorter, and the size afterwards rapidly decreases to umbilicus. Second and third saddles are bifid. Antisiphonal lobe a little deeper than lobe next to it, but not nearly so deep as the decline of the whole suture-line on umbilical margin. Lobes all simply bifid.

The specimens that have been described show a close resemblance to the specimens of *Gaudryceras kayei* in the collection at the British Museum, Natural History Branch, at South Kensington. These are in the collection made by Kaye and described by Forbes. In the New Zealand specimens the periphery is somewhat flatter, sculpture coarser on umbilical surface, and finer on peripheral region, where also striae have a stronger forward bend. The width which Stoliczka mentions as so remarkable is still more marked than in the Indian specimens of the Kaye collection, though the measurements of the drawings given by Stoliczka show proportions almost exactly the same as in the New Zealand specimens. Yabe (37, p. 25) suggests that various specimens of *G. kayei* from South India, as well as Steinmann's specimens from Quiriquina, and the Griesbach specimen from South Africa, should be included in his species *Gaudryceras tenuiliratum* var. *ornatum*. The specimen of this species figured by him is, however, clearly a close relative of *G. sacya*, and quite different from the true

G. kayei in form and sculpture. The specimen in the Griesbach collection has now rightly been recognized as a distinct species by van Hoepen, and he has named it *G. varicostatum*, which, as shown in this paper, is quite close to the New Zealand species *G. semileve*. *G. jukesi* Sharpe in Whiteaves (8) is certainly this species, and is quite different from the species that he refers to under *G. jukesi* later (27). There is no description of the forms identified by Anderson in California and by Kilian and Reboul in Seymour Island as *G. kayei*, but there is little doubt that they are typical forms of this species.

This species has been found at Batley and Bull's Point in the Kaipara, and plentifully at Whangaroa, where it seems to be the species called *Desmoceras* sp. by Clarke (47, p. 56, pl. 12, fig. 3 *a*, *b*).

Three specimens in the Auckland Museum come from Hokianga.

It is stated by Kossmat, and the remark is quoted by Kilian and Reboul, that *G. kayei* Forbes is closely related to *G. planorbiforme* Bohm from the Upper Cretaceous of Bavière. I have no specimens of this species for comparison, but, basing my opinion upon the description and figures given by de Grossouvre, I am unable to agree that the relationship is close. The specific name is given in memory of the late R. Murdoch, a well-known New Zealand conchologist.

GAUDRYCERAS de Grossouvre (19, p. 225).

The following is the diagnosis of the genus given by de Grossouvre: "Ce genre est caracterisé par l'allure des striés de la coquille partant de l'ombilic, infléchies en avant, et par une ligne suturale formée de lobes et de selles assez nombreux, les lobes étant tous à terminaison paire." He lays stress on the striae being directed back from the edge of the umbilicus. The sutural line is not so much reduced in auxiliaries as in *Lytoceras*. In the greater number of species the whorls increase slowly, and are but slightly involute in the young, but afterwards increase more rapidly, especially in height.

Kossmat later emended the description (28, p. 113). Slightly involute forms, with periodic constrictions forming bolsters on the shell or furrows on the cast. These, like the fine wire-like ribs, start at right angles to the umbilicus, and in the under half of the flank bend forward and in the upper half backward, forming a shallow forward bend on the periphery. The suture-line is of the greatest importance for the whole group. The median saddle is small, like a spear; the external lobe long and small, as deep as the first lateral lobe. The bifid external saddle is conspicuous. There are always several auxiliary lobes, which form a distinct umbilical lobe. In the internal portion there is a small and deep antisiphonal lobe, which goes as far back, or farther, than the umbilical lobe. A long tree-like saddle separates the two lobes, and on its side it is deeply dissected by sharp points. The bottom of the deep highly characteristic umbilical lobe is two-pointed, like the antisiphonal lobe. (*Translation of extract.*)

The nature of this internal suture-line separates *Gaudryceras* from *Tetragonites*. All species of *Gaudryceras* have at the base of the partition wall a single deep groove which corresponds in position to the antisiphonal lobe, while *Tetragonites*, with a greater number of internal lobes, has more than one on each side of the antisiphonal line.

Gaudryceras propemite n. sp. (Plate 20, fig. 4; Plate 28, figs. 3, 4.)

Compare—

1865. *Ammonites sacya* var. *multiplexus* Stol. (11, p. 155, pl. 76, fig. 1).
1866. *Lytoceras mite* von Hauer, Neue Cephalopoden der Gosaugebilde, *Sitz. Akad. der Wiss. Wien*, Bd. 53, p. 7, Taf. 2, figs. 3, 4.
1873. *Ammonites sacya* var. *sachalinensis* Schmidt (4, p. 15, Taf. 2, figs. 1, 2, 6.
1893. *Gaudryceras mite* Hauer, in de Grossouvre (19, p. 227, pl. 26, fig. 4; pl. 39).
1895. *Gaudryceras jukesi* Sharpe, in Whiteaves (27, p. 129, pl. 2, figs. 1, 2).
1895. *Lytoceras* (*Gaudryceras*) *multiplexum* Koss. (28, p. 121, pl. 15, fig. 6).
1907. *Lytoceras varagurense* var. *patagonicum* Paulcke (42A, p. 6, Taf. 17, figs. 1, 2).
1917. *Gaudryceras* aff. *jukesi* (Whiteaves) Sharpe, in Woods (57, p. 35, pl. 20, fig. 2).

Dimensions:—

	A.		B.		C.		D.	
Diameter	64	100	78	100	101	100	64	100
Height of last whorl	24	37	23	29	40	40	25	40
Width of last whorl	28	44	24	30	38	38	26	41
Umbilicus	19	30	38	49	35	35	24·5	39

A, *Gaudryceras propemite*, Bull's Point, Kaipara Harbour, N.Z.; B, *Lytoceras* (*Gaudryceras*) *multiplexum* Koss. (28, p. 121, Taf. 15, fig. 6); C, *Lytoceras* (*Gaudryceras*) *varagurense* (28, p. 122, Taf. 18, fig. 2, pl. 17, fig. 9); D, *Lytoceras* (*Gaudryceras*) *vertebratum* Koss. (28, p. 126, Taf. 15, figs. 4, 5).

The dimensions given above show that the breadth and height of the whorl are almost equal, and that they come nearest to *G. vertebratum* of the Indian species.

Form discoidal, with an involution of one-third. Seven whorls when diameter is 64 mm., with its greatest thickness just above slope to umbilicus; from this point there is a gradual slope to periphery, which is evenly rounded. Whorls slightly wider than high; whorls do not increase rapidly in height.

Ornamentation: A large number of rounded ribs of moderate size, which on body-chamber begin rather indistinctly near base of umbilical wall. They rapidly increase in distinctness, and at top of umbilical slope many divide into two, and other interstitial ribs arise, their number being increased about twofold. Ribs at first almost radial, but soon bend strongly forward, then distinctly backward, and at periphery again slightly forward so that they cross it with a slight forward curve. Ornamentation of inner whorls the same up to the point where they are covered by the next succeeding whorl; here they break up into striations, and similar additional striations arise interstitially and cross periphery with a slight forward bend. There are periodic furrows, sometimes very distinct, about four in a whorl.

Suture-line does not differ to any important extent from that of the different coarse-ribbed forms of *Gaudryceras* from South India which have been mentioned above. On the whole, it is rather more like that of *G. vertebratum* than the others. The most distinctive character is in the development of the median secondary saddle in the first lateral lobe.

The species is evidently very close to the *G. vertebratum-varagurense* group in all respects, but in none of them is there any mention of the curious change in the nature of the sculpture in all of the inner whorls. *Gaudryceras cinctum* Spath, from Pondoland, is also close, as is *G. mite* Hauer, from the Santonian of Europe. Again, *G. varagurense* var. *patagonica* Paulcke, from Patagonia, is closely related, but the details of the ornamentation seem to be distinct. *G. varagurense* and *G. mite* have been recorded by Kilian and Reboul from Seymour Island, but in both cases

it appears that the state of preservation does not allow any details of the ornamentation to be seen.

A single complete specimen has been found at Bull's Point, as well as several fragments.

G. multiplexum and *G. vertebratum* come from the Utatur formation, and *G. varagurense* from the Upper Trichinopoly (= Lower Senonian) of Europe.

Gaudryceras particostatum n. sp. (Plate 20, fig. 7; Plate 30, figs. 3, 4.)

Compare—

1906. *Gaudryceras kayei* Forbes, in Woods (40, p. 335, pl. 41, fig. 8).
1921. *Gaudryceras varicostatum* van Hoepen (52, p. 7, pl. 2, figs. 10–12, text-figs. 3, 4).
1922. *Gaudryceras varicostatum* van Hoepen, in Spath (54, p. 117).

Dimensions:—

	A.		B.		C.		D.	
Diameter	27	100	24	100	33	100	39·6	100
Height of last whorl	10	37	9	38	13	39	13·7	35
Width of last whorl	10	37	9	38	11	34	14·7	37
Umbilicus	10	37	11	45	13	39	17·2	43

A, B, C, *Gaudryceras particostatum*. Bull's Point, Kaipara Harbour, N.Z.; D, *Gaudryceras varicostatum* van Hoepen (52, p. 7).

The dimensions show at once that height and width of whorl are almost equal, and umbilicus extremely wide. Shell small, with whorls that show little involution and do not increase rapidly in size. Umbilicus wide, with a nearly uniform slope. When the radius is 14 mm. six whorls are developed. The umbilical slope is steep, but passes by a rapid curve into the flank, which slopes steeply to the well-rounded periphery.

Ornamentation: Flanks of inner whorls covered with thin wire-like ribs, which begin at umbilicus and at once bend sharply forward. At edge of periphery, where whorl is covered by the succeeding one, the wires change into a number of minute striations, which require a high-powered lens to show them up. These have a slight bend forward where they cross periphery. On body-chamber the wire-like ornamentation cannot be seen, and its place is taken by fine striations; these are not easily seen, and without a careful inspection the surface appears to be smooth. Four conspicuous constrictions in a revolution.

Suture-line in both external and internal portions very similar to that of *Gaudryceras varicostatum*. Antisiphonal lobe differs from typical form in its greater breadth. External portion of suture-line is quite typical of the genus, though, on the whole, it is perhaps rather less deeply dissected. Umbilical lobe unusually deep and extremely steep. The width of the single saddle in the internal portion of the suture-line is noticeable, and in this respect this species resembles *G. propemite*, *G. varicostatum*, and *G. varagurense*, though it is less marked in the last species.

This species certainly comes nearer to *Gaudryceras varicostatum* than to any other that could be found in the available literature. It is, however, distinguished by the finer ribbing and the somewhat higher whorl. There seems to be no Indian species to which it shows a close resemblance, for it has a higher whorl and smaller umbilicus than *G. multiplexum*; finer ribbing and a wider umbilicus than *G. varagurense*; a narrower and lower whorl than *G. vertebratum*, and finer ribbing as well; and in none of these species has it been recorded that the ribbing changes in its character on the upper part of the flank.

Several good specimens have been obtained at Bull's Point, and one in poor condition from Whangaroa. In the Auckland Museum there is a specimen in good condition labelled as coming from Morant's Island, in the Kawhia Harbour. This, however, I regard as a mistake, as the rocks on that minute island are entirely Tertiary in their age. It is possible that this and *Baculites rectus* n. sp., which have the same matrix, come from Hokianga or from Kaipara.

Gaudryceras subsacya n. sp. (Plate 20, figs. 8, 8*a*; Plate 29, figs. 1, 2.)

Com

1846. *Ammonites sacya* Forbes (1, p. 113, pl. 14, fig. 10).
1846. *Ammonites buddha* Forbes (1, p. 112, pl. 14, fig. 9).
1865. *Ammonites sacya* Forbes, in Stol. (11, p. 154, pl. 75, figs. 5–7; pl. 76, figs. 1, 2, 3).
1873. *Ammonites sacya* var. *sachalinensis* Schmidt (4, p. 15, pl. 2, figs. 3, 4).
1876. *Ammonites filicinctus* Whiteaves (7, p. 43, pl. 2, figs. 2, 3).
1884. *Lytoceras sacya* Forbes, in Whiteaves (7, p. 203, pl. 25).
1890. *Lytoceras sacya* Forbes, in Yokoyama (17, p. 178, pl. 18, fig. 12).
1894. *Lytoceras sacya* Forbes, in Jimbo (22, p. 34, pl. 6, fig. 1).
1894. *Lytoceras sacya* Forbes, in Stanton (20, p. 445).
1895. *Lytoceras* (*Gaudryceras*) *sacya* Forbes, in Koss. (28, p. 119).
1902. *Lytoceras* (*Gaudryceras*) *sacya* Forbes, in Anderson (33, p. 82).
1903. *Gaudryceras tenuiliratum* Yabe (48, p. 19, pl. 3, figs. 3, 4; also var. *ornata*, pl. 3, fig. 2).
1903. *Gaudryceras striatum* var. *pictum* Yabe (48, p. 33, pl. 4, fig. 3).
1917. *Gaudryceras sacya* Forbes, in Woods (57, p. 11, pl. 5, figs. 4 *a*, *b*).
1917. *Lytoceras* sp. Marshall (49, p. 445, pl. 33, fig. 3, text-fig. 4).
1921. *Gaudryceras sacya* Forbes, in Spath (59, p. 54).

Dimensions :—

	A.		B.		C.		D.		E.		F.		G.	
Diameter ..	28	100	22·75	100	36	100	29	100	24	100	16	100	45	100
Height of last whorl	10·5	37	9	39	12·5	35	11	38	9	37	6·2	39		33
Width of last whorl	10·75	42	10·25	45	14	39	12	41	10·25	42	8	50		34
Umbilicus ..	11·5	41	10	44	13·5	38	11·25	39	9	37	7	44		44

	H.		J.		K.		L.		M.		N.		P.	
Diameter ..	95	100	40	100	50	100	120	100	113	100	300	100	35	100
Height of last whorl		43		30		34		40	50	44	160	53	12	34
Width of last whorl		36		35		30		38	45	40	165	53	13	38
Umbilicus ..		32		50		46		36	36	32	55	18	15	42

A, B, C, D, E, F, *Gaudryceras subsacya*, Bull's Point and Batley, Kaipara Harbour, N.Z.; G, H, J, K, L, *Gaudryceras sacya* Forbes, in Stolicka (11, p. 154, pl. 75, figs. 5–7; pl. 76, fig. 23); M, *Gaudryceras sacya* Forbes, in Kossmat (28, p. 119); N, P, *Gaudryceras tenuiliratum* Yabe (37, p. 19).

The six specimens of *G. subsacya* that were measured show at once that the species always has a whorl that is wider than high, and that the larger specimens are both lower and narrower than smaller ones. The Indian specimens that were measured by Stoliczka are in most cases higher than wide, and this is also the case in the Indian specimen quoted by Kossmat. Yabe's measurements of *Gaudryceras tenuiliratum* are much higher and wider in the large specimens than in the smaller. The measurements show that species is characterized by its uniformly wide whorl.

Shell discoidal with wide umbilicus, downward slope of which is modified by rounded contour of inner whorls. Involution about one-third. Slope from umbilicus steep, and gradually rounds off into flank; periphery flattened. Well-preserved specimens show five distinct constrictions marked

on shell by prominent rounded ribs, which have a large furrow behind and a smaller one in front. Regular sculpture consists of extremely numerous ribs, so fine that when radius is 7 mm. there are 45 on an arc of periphery 5 mm. in length. Large ribs that mark constrictions are covered with these fine ribs, which arise at bottom of umbilical slope and at first have a slight forward inclination. This soon becomes pronounced, but decreases again at about two-thirds of distance from umbilicus. Ribs cross periphery with the very slightest forward bend. Near top of umbilical slope an interstitial rib arises between each pair, and all continue without interruption across periphery. Ribs and sculpture on body-chamber differ in no respect from those on younger whorls, except in size, which increases proportionately to diameter.

Suture-line is typical of the smaller species of *Gaudryceras*, and by itself can hardly be distinguished except by the slightly displaced position of the small secondary saddle in the first lateral lobe. Internal portion of suture-line also is quite typical of these smaller species, and shows the long and narrow single saddle which Kossmat considers an essential feature of the genus.

The position of this species is very close to *G. tenuiliratum* var. *ornatum* of Yabe; but comparison of the measurements shows that the whorl is both higher and wider than in the Japanese species, and at the same time the umbilicus is narrower. The resemblance to *G. striatum* var. *pictum* of Yabe is also close, but the ribs appear to be much more flexuous in that species. The specimens considered to be *G. sacya* by Yokoyama and Jimbo are differently classed by Yabe. Crick's specimen of *G. pulchrum* in the South Kensington Museum was also compared with those from New Zealand, and it was found that its ribs were distinctly sharper and farther apart than in the present species. Forbes's type of *G. sacya* is also in the Museum, and though it is in poor condition it is clear that the ribs are a little larger and farther apart than in the New Zealand examples. The species appears to be very similar to *G. filicinctus* of Whiteaves from the Queen Charlotte Islands. The examples here described from the north of New Zealand are quite close to the specimen from the Clarence Valley of the South Island of New Zealand, which was classified by Woods as *G. sacya*, for the only observable difference in that the ribs in the South Island specimen are rather coarser than those of all but one of the specimens from the North Island.

This species is common at Batley and at Bull's Point in the Kaipara Harbour, but no specimens were found at Whangaroa.

Gaudryceras sacya comes from the Lower Utatur group. No specimen yet found in New Zealand shows the corrugations which characterize the mature forms of *G. sacya* as figured by Whiteaves and of *G. limatum* figured by Yabe.

Gaudryceras politissimum Kossmat. (Plate 20, fig. 3; Plate 28, figs. 1, 2.)

Compare—

1895. *Gaudryceras politissimum* Koss. (28, p. 128, Taf. 15, figs. 7 *a*–*c*).
1907. *Lytoceras* (*Gaudryceras*) *politissimum* Koss., in Kilian and Reboul (46, p. 14, pl. 1, figs. 7, 8).

Dimensions :—

	A.		B.	
Diameter	48	100	89	100
Height of last whorl	20	49	33	37
Width of last whorl	14	29	28	31
Umbilicus	16	33	34	38

A, *Gaudryceras politissimum* Koss., Bull's Point, Kaipara Harbour, N.Z.; B, *Gaudryceras politissimum* Koss. (28, p. 128).

These dimensions show that the only specimen that is in good enough condition to be measured has a whorl a little higher than that of Kossmat's type, while the umbilicus is distinctly narrower. Comparisons with the dimensions of *G. subsacya* show that the whorl in that species is not so high as, but is much wider than, that of *G. politissimum.* In the specimen that has been measured the greater part of outer whorl is somewhat compressed. The inner whorls increase a good deal in their relative width, the penultimate whorl measuring—height, 4·5 mm.; width, 5·5 mm.; and the whorl next to that—height, 2·5 mm.; width, 3·5 mm. The broadest part of outer whorl is at top of umbilical wall, where there is a sharp curve to the gently sloping flank; but at periphery the curve is much sharper.

Ornamentation: Five constrictions can be distinguished in the last whorl, which appear as rounded ribs on the shell. They are low where they leave umbilicus. They at once bend forward and increase in size, but the forward curve is soon reduced, and they cross periphery with a slight forward bend. At first sight the surface of the shell appears to be polished, but when examined with a lens a number of regular but extremely fine hair-like ribs can be distinguished. About every tenth or fifteenth of these is larger. They start almost straight from the umbilicus, or with a slight backward trend. They soon bend forward on the edge of umbilicus; then they straighten up, but pass over periphery with a broad forward curve.

Suture-line agrees fairly well with that of *G. politissimum* figured by Kossmat. The saddles, however, are less divided, the slope to umbilicus begins sooner, and there are fewer auxiliary saddles; umbilical lobe is also deeper.

The specimen agrees quite well with description that has been given by Kossmat, though the relative height and width of inner whorls are not referred to by him. The ornamentation and also the form of *G. politissimum*, *G. subtilineatum* Koss. (28, p. 123), and *G. valudayurense* Koss. (28, p. 127) are very similar, but it appears that the ornamentation of the surface of *G. valudayurense* is rather stronger and the suture-line is rather more divided. It would be extremely difficult to distinguish the inner whorls of the New Zealand specimen of *G. politissimum* from those of *G. subtilineatum* described by Kossmat.

One specimen, in moderately good condition, from Bull's Point, and a second, of the inner whorls only, from Batley.

Gaudryceras crenatum n. sp. (Plate 20, fig. 10; Plate 31, figs. 3, 3*a*.)

Dimensions:—

	A.	
Diameter	27	100
Height of last whorl	9	33
Width of last whorl	10	37
Umbilicus	12	44

A, *Gaudryceras crenatum*, Bull's Point, Kaipara Harbour, N.Z.

Shell discoidal, with wide umbilicus which has very even slope. Involution about one-third. A steep even slope of umbilical wall, which curves rather quickly into flank, and therafter a uniform curve which passes without interruption over rounded periphery.

Ornamentation: Four shallow periodic furrows in last whorl, with occasionally a low rounded rib behind. The surface appears bright and shining, but examination shows that it is closely covered with fine thread-like ribs. These arise at umbilicus and are at first straight, but soon bend

forward and maintain this direction until they reach beyond umbilical edge; they then bend slightly backwards, but soon again bend forward and pass with a broad curve across periphery. Ribs become less distinct at periphery, but there are no interstitial ribs. Ribs have a sharp crest, but are distinctly crenate on backward side. A good specimen and a high-power lens are necessary to reveal this structure.

Suture-line not well seen. Saddles not so highly divided as in the other species of *Gaudryceras*. External lobe is perhaps a little deeper than usual, and three auxiliary lobes are present.

Three specimens only, two of which come from Bull's Point and one from Batley.

The crenation of the small ribs is the most distinct characteristic of this species. So far as Cretaceous species of this family are concerned, it has been recorded only in *Lytoceras mahadeva* Stol., from the Lower Utatur of India; *L. batesi*, from the lower beds of Queen Charlotte Island of British Columbia; and *L. ezoense*, from the Lower Ammonite beds of Japan. These are included in the *Lytoceras fimbriatum* group of Kossmat, which is mainly distinguished by the absence of auxiliary lobes and saddles in suture-line (28, p. 112). The present species has three auxiliary lobes and saddles, and at the same time its small size and fine ribbing ally it rather to the *Gaudryceras* group. It is perhaps permissible to regard the crenation as a vestigial remnant that shows clearly the lytoceratid ancestry.

ZELANDITES n. gen.

This genus is suggested for some ammonites that could not be placed in any of the genera of which detailed descriptions and literature were available. The ornamentation is so similar to that of several species of *Gaudryceras* that it seems necessary to place it close to that genus. The narrow and high whorl has the general form of that of *Gaudryceras varuna*, which has been recorded from Quiriquina by Steinmann as well as from its original locality. On the other hand, the suture-line, so far as its general appearance is concerned, and especially in the nature of the first lateral lobe, is so peculiar that it becomes doubtful if the species should be included in the Lytoceratidae. However, in the absence of specimens of allied species for comparison, and of more extensive literature, it has been placed here provisionally.

Zelandites kaiparaensis n. sp. (Plate 20, figs. 9, 9*a*; Plate 31, figs. 1, 2.)

Compare—

1845. *Ammonites varuna* Forbes (1, p. 107, pl. 8, fig. 5).
1865. *Ammonites varuna* Forbes, in Stol. (11, p. 111, pl. 58, fig. 1).
1894. *Desmoceras kawanoi* Jimbo (22, p. 28, pl. 1, fig. 7 *a*, *b*).
1895. *Lytoceras (Gaudryceras) odiense* Koss. (28, p. 129, pl. 18, fig. 1 *a–c*).
1895. *Lytoceras (Gaudryceras) varuna* Forbes, in Koss. (28, p. 130, pl. 16, fig. 4 *a–b*: pl. 17, fig. 8).
1895. *Lytoceras varuna* Forbes, in Steinmann (26, p. 84, Taf. 5, fig. 2 *a*, *b*; text-fig. 7).
1903. *Gaudryceras kawanoi* Jimbo, in Yabe (37, p. 41).

Dimensions:—

	A.		B.		C.		D.	
Diameter	25	100	18	100	23	100	26	100
Height of last whorl ..	12	48	8	44	12	53	13·5	52
Width of last whorl ..	7·45	30	6·5	35	7·5	33	7	27
Umbilicus	6·5	26	5	28	4·5	20	5·2	20

A, B, *Zelandites kaiparaensis* n. sp., Bull's Point, Kaipara Harbour, N.Z.; C, *Lytoceras (Gaudryceras) varuna* Forbes, in Koss. (28, p. 161); D, *Lytoceras varuna* Forbes, in Steinmann (26, p. 84).

The dimensions show a fairly close resemblance to *Gaudryceras varuna*, though the whorl of the New Zealand species is not so high and the umbilicus is a good deal wider.

Shell small, discoidal, with an involution of about two-thirds. The greatest width is just above umbilicus, to which the slope is steep, though it rounds off gradually at top of wall; thence the flanks slope gradually to periphery, which is narrow and sharply rounded. Body-chamber has the length of two-thirds of a revolution. Surface of inner whorls covered with fine hair-like ribs, at first strongly inclined forwards, but at top of umbilical slope they become straight and pass straight over periphery. Body-chamber has the same ornamentation as inner whorls. Nine deep constrictions in a whorl. They are at first radial in direction, but soon take a strong bend forward, and near periphery become radial again, passing over it with a barely noticeable backward curve. These constrictions are visible on the shell and have no ribs before or behind.

Suture-line peculiar, and the absence of much literature makes it hard to classify the species. The median saddle is sharp and has a few jags on side. External saddle high and bifid, with a much larger development on external than on internal side. The two lateral saddles are also bifid, but are much smaller, and seven auxiliary saddles can be distinguished. All divisions of the saddles have deep and sharp jags, which give rather a distinct appearance. External lobe about as deep as first lateral lobe, and rather wide. First lateral lobe wide, and the small secondary saddle in the middle is much less conspicuous and important than in *Gaudryceras*. There are larger projections on either side of it, and of these the internal one is by far the largest element in the whole. This is similar to the same lobe in *Diplomoceras cylindraceum* Defr. (47A, fig. 1259: 45, Taf. 45, fig. 47) and to that in *D. wakanene*, figured in this paper (Plate 19, fig. 3), but it is quite different from that in the four Indian species of *Anisoceras* Pictet = *Diplomoceras* Hyatt figured by Kossmat (28, Taf. 19). The other lobes present no unusual features. Auxiliary lobes and saddles highly inclined, and form a deep umbilical lobe. Internal portion of suture-line not much different from that of *G. semileve* or *G. propemite*, or of *G. varicostatum* van Hoepen, and approaches that of *G. varagurense* as drawn by Kossmat. In the three first-mentioned at least it may be said that there is a single wide and rapidly thinning saddle, which is high, while smaller saddles are represented by projections on its outer side. This is certainly distinct from the single thin and high saddle of *G. subsacya* and *G. vertebratum* as drawn by Kossmat.

The form of this species shows affinities with that of *G. varuna* and *G. kawanoi*, while the ornamentation is similar to the general characters of that of *Gaudryceras*.

Four specimens, all of them from Bull's Point, on the Kaipara Harbour. A specimen of a closely allied species is in the collection of the New Zealand Geological Survey. It was found by McKay at Awanui, near East Cape, in Cook County. It differs from the Kaipara form in ornamentation, as it is almost destitute of ribs, but in form and suture-line it differs but little.

Tetragonites Kossmat, 1895.

Whorls strongly involute and rapidly increasing. Cross-section trapezoidal, the broadest part near umbilicus; flanks and periphery flattened. Fine growth-lines only, and usually periodic growth forms bolsters on the shell and deep constrictions on the cast. Siphuncular saddle lance-shaped; external lobe same depth as first lateral lobe, which has a median secondary saddle. Several auxiliary saddles. Internal portion of suture-line may have

as many as four saddles, which are bifid like saddles of external portion. The genus begins with *T. duvalianum* in the Neocomian, and extends in a single Indian species into the Senonian.

The above is a brief summary of the generic diagnosis given by Kossmat (28, p. 131).

Tetragonites epigonus Kossmat. (Plate 21, fig. 10; Plate 29, figs. 6, 7.)

Compare—

1865. *Ammonites timotheanum* Mayor, in Stol. (11, p. 146, pl. 73, fig. 5).
1895. *Lytoceras* (*Tetragonites*) *epigonum* Koss. (28, p. 135, Taf. 17, figs. 4 *a*, *b*, *c*, 5 *a*, *b*).
1907. *Lytoceras* (*Tetragonites*) *epigonum* Koss., in Paulcke (42A, p. 8).
1909. *Lytoceras* (*Tetragonites*) *epigonum* Koss., in Kilian and Reboul (46, p. 14).

Dimensions:—

	A.		B.		C.		D.	
Diameter	38	100	59	100	23	100	28	100
Height of last whorl	20	53	26	44	10	43	11	39
Width of last whorl	22	58	27	46	11	44	12	43
Umbilicus	8	21	15	25	7	30	..	

A, *Tetragonites epigonus* Koss., Bull's Point, Kaipara Harbour, N.Z.; B, C, *Lytoceras* (*Tetragonites*) *epigonum* Koss. (28, p. 135); D, *Lytoceras* (*Tetragonites*) *epigonum* Koss., in Paulcke (42A, p. 8).

Shell discodial but whorls increasing rapidly in size. Involution about one-half, and umbilicus small but deep. Whorls wider than high. Umbilical wall almost vertical but soon curving rapidly into flank, which is gently rounded and passes without any sudden angle into periphery. Thickest part of whorl just above umbilicus. Surface appears smooth and polished, but examination shows it traversed by fine lines which arise radially on the steep slope of umbilicus, then bend forward, but soon change again and cross periphery with a slight curve backward. There are deep constrictions, most pronounced on middle of flanks but soon fade away towards periphery and in umbilicus; there are five in a revolution, and they follow the same general course as the striations.

Suture-line very similar to that of *Pseudophyllites indra*, and I fail to find any important differences in the figures given by Kossmat for the two species and also in the specimens found in New Zealand. The internal portion of suture-line shows a similarity to the figure of Kossmat, but the saddles are less divided and the saddle nearest to umbilical surface is relatively shorter.

One specimen at Bull's Point, and one at Batley.

Tetragonites latus n. sp. (Plate 20, figs. 6, 6*a*; Plate 32, figs. 1, 2.)

Compare—

1847. *Ammonites timotheanus* Pictet and Roux; also the same species in Stoliczka, Schmidt, Whiteaves, Anderson, and Kossmat.
1903. *Tetragonites glabrus* Jimbo, in Yabe (37, p. 43, pl. 7, figs. 2, 5).
1907. *Tetragonites kingianum* var. *involutior* Paulcke (42A, p. 9, Taf. 17, figs. 3 *a*, *b*, 4 *a*, *b*).
1921. *Tetragonites superstes* van Hoepen (52, p. 11, pl. 2, figs. 17–20, text-fig. 6).

Dimensions:—

	A.		B.		C.		D.		E.		F.	
Diameter .. .	19	100	13	100	13·5	100	80	100	32·4	100	35	100
Height of last whorl.	9·5	50	7	54	7·3	54	41	50	14·2	44	17	48
Width of last whorl.	11	58	7·7	59	8	59	45	56	15·5	48	19	54
Umbilicus .. .	3	16	2	16	2	15	16	20	8·3	26	8	21

A, B, *Tetragonites latus*, Bull's Point, Kaipara Harbour, N.Z.; C, *Tetragonites latus*, Batley, Kaipara Harbour, N.Z.; D, *Tetragonites timotheanus* Pictet, in Koss. (28, p. 133, Taf. 17, figs. 11, 13 *a*, *b*); E, *Tetragonites superstes* van Hoepen (52, p. 11, pl. 2, figs. 17–20, text-fig. 6); F, *Tetragonites glabrus* Jimbo, in Yabe (37, p. 43, pl. 7, figs. 2, 5).

Shell small, discoidal, somewhat inflated and involute. Four whorls only in a radius of 10 mm. Whorls rise very steeply from umbilicus, where there is a distinct rounded angle, and afterwards a uniform curve to periphery, which is slightly flattened. Whorls always distinctly wider than high, and increasing rapidly, thus forming a deep and narrow umbilicus.

Ornamentation: The surface is practically smooth, but longitudinal grooves can be seen distinctly. There is one on each side of the median line, about 1½ mm. distant from it in the largest specimen. There is another, less distinct, where the whorl curves from the flat periphery to the flank. These spiral lines are not distinct in all specimens.

Surface of shell appears to be bright and shining, but is actually marked by very fine indistinct and irregular striations, between which low rounded ribs can be distinguished. These bend forward slightly at first, then cross periphery without change. Spiral lines of a similar nature to those seen in this species have been recorded in *T. superstes* by van Hoepen, and in the related genus of *Pseudophyllites* in the species *garuda* by Stoliczka which is included in the species *indra* by Kossmat. No periodic grooves whatever can be seen on any of my specimens. The body-chamber shows for half a revolution in one specimen, but it is not complete. Suture-line shows that the first lateral lobe is unusually wide. Divisions of saddles and lobes very simple. Second lateral saddle is already on slope of umbilicus. Three auxiliary lobes and saddles. Internal portion of suture-line has a deep antisiphonal lobe and two saddles nearly equal in height, but projections on outer side of second saddle may represent partially suppressed saddles.

This species differs from the widely-distributed *T. timotheanus* in the entire absence of constrictions, and from this and apparently from all other closely related species in the great width of whorl and the narrowness of umbilicus. It is perhaps nearer to *T. superstes* van Hoepen than to any other. *T. kingianum* var. *involutior* Paulcke is quite close to this species, but has a wider umbilicus.

Several specimens have been obtained from Batley, Bull's Point, Whangaroa, and perhaps *Tetragonites* sp. juv. Spath (53, p. 300) from Selwyn Rapids is the same species.

Tetragonites simplex n. sp. (Plate 20, figs. 11, 11*a*; Plate 32, figs. 3, 4.)

Compare—

1845. ***Ammonites cala*** Forbes (1, p. 104, pl. 8, fig. 4).
1865. ***Ammonites cala*** Forbes, in Stol. (11, p. 153, pl. 75, fig. 4).
1895. ***Lytoceras (Tetragonites) cala*** Forbes, in Koss. (28, p. 136, 163, Taf. 17, figs. 12 *a–d*).
1921. ***Tetragonites nuperus*** van Hoepen (52, p. 13, pl. 3, figs. 3, 4, text-fig. 8).
1922. ***Tetragonites nuperus*** van Hoepen, in Spath (54, p. 119).

Dimensions :—

	A.		B.		C.		D.		E.	
Diameter ..	19	100	21	100	20	100	80·5	100	37·6	100
Height of last whorl	7	31	7·5	35	8	40	25	31	14	37
Width of last whorl	7·2	37	8	42	8·4	42	29	37	15·4	41
Umbilicus ..	7·6	40	8	42	7	35	38	47	15·5	41

A, B, C, *Tetragonites simplex* n. sp., Batley, Kaipara Harbour, N.Z.; D, *Tetragonites cala* Forbes, in Koss. (28, p. 163); E, *Tetragonites nuperus* van Hoepen (52, p. 13).

Shell small, discoidal, slightly involute, about one-quarter and therefore with a wide umbilicus. Five whorls in a 10 mm. radius. Whorls rise steeply from umbilicus and curve sharply, almost with an angle, to the evenly-rounded flanks, and pass with another sharp curve or angle to the much-flattened periphery. The section of a whorl is not truly

angular, though the curves are rapid. Surface of shell quite smooth and polished. There are three conspicuous constrictions on the cast in each whorl, but they cannot be distinguished on the shelly matter. They commence on edge of umbilicus and bend sharply forward, becoming much less distinct towards periphery, which they cross with a low forward curve.

Suture-line very simple. Median saddle rounded. External saddle with three simply rounded projections which are less distinct on first lateral saddle and just indicated on second. The five auxiliary saddles are quite simple. First lateral lobe has one simple secondary saddle.

This species is close to *Tetragonites nuperus* van Hoepen, but the suture-line is a good deal simpler, and in this respect it resembles *G. rouvillei* de Grossouvre (19, p. 288, pl. 37, fig. 10), though it seems to be quite different from the larger form, fig. 7. It differs from *T. cala* Forbes in the less angular whorl-section and in the simpler suture-line. *Tetragonites kingianum* var. *involutior* is much less inflated, and has a more complex suture-line. In suture-line and in general aspect this species shows a great resemblance to *G. bucculentum* Pervinquière (*Mem. Geol. Soc. de France*, 17, Fasc. 2, 3, 1910).

This is not an uncommon species at Bull's Point and Batley; a specimen has also been found at Whangaroa.

Tetragonites margaritatus n. sp. (Plate 20, fig. 5; Plate 30, figs. 5, 6.)

Compare—

1903. *Tetragonites popetensis* Yabe (37, p. 48, pl. 7, figs. 4 *a*, *b*, 6).
1907. *Lytoceras* (*Tetragonites*) *kingianum* var. *involutior* Paulcke (42A, p. 8, pl. 17, figs. 3 *a*, *b*, 4 *a*, *b*).

Dimensions:

	A.		B.		C.		D.		E.	
Diameter	15·5	100	12	100	11·5	100	34	100	20·5	100
Height of last whorl ..	7	45	4·7	39	5	43	14·5	43	9	43
Width of last whorl ..	8	51	5	42	5·5	49	15	44	9	43
Umbilicus	5	32	4	35	4	36	10·5	30	5·5	26

A, B, *Tetragonites margaritatus*, Batley, Kaipara Harbour, N.Z.; C, *Tetragonites margaritatus*, Bull's Point, Kaipara Harbour, N.Z.; D, E, *Tetragonites popetensis* Yabe (37, p. 48, pl. 7, figs. 3 *a*, *b*, 4 *a*, *b*).

A very small species, of which there are five examples. Shell is discoid, with an involution of about one-half. Wall of umbilicus steep, but passes quickly into circular curve of flanks and periphery, though the latter is distinctly flattened. Whorls increasing rather rapidly. Umbilicus deep, its slope interrupted by curved surface of whorls, of which there are five in a radius of 8 mm. In one specimen body-chamber is three-quarters of a revolution, but it is not complete. Surface of shell perfectly smooth, and in the type specimen pearly, though a few very indistinct growth-lines can be distinguished. There are occasional deep constrictions which bend strongly forward from bottom of umbilicus until they reach half-way across the flanks, from which point they extend straight to periphery and cross it without change. No more than two can be seen in a revolution. Suture-line with six saddles, well divided considering the small size of the shells. Saddles high and narrow, and there are three auxiliary saddles. On the whole, the suture-line is quite characteristic of the smaller species of *Tetragonites*.

A number of specimens were found at Batley, and two at Bull's Point.

This species closely resembles *T. popetensis*, but the umbilicus is rather wider than in that species. The smoothness of the surface of the present

species is another distinction. Umbilicus wider and whorls more projecting than in Paulcke's species *T. kingianum* var. *involutior* from South Patagonia.

Pseudophyllites Kossmat, 1895.

Kossmat gives no definite statement of the characteristics of the genus, but from the description of the only species of it that he recognizes the following statement may be taken as embodying the essential features:—

Strong involution, rapid increase especially in the later stages of growth, and very small umbilicus. The whole surface covered with very fine hair-like lines which bend backwards at periphery; there are also broad bands which may be 5 mm. apart, but no constrictions. In the young the suture-lines are phylloid, and the external and first lateral saddles are trifid. Kossmat states that in the larger examples the inner division lobe in the trifid external saddle is the deeper, and the outer division lobe of the first lateral saddle is the deeper. The unsymmetrical nature of the external and first lateral saddles distinguishes *Pseudophyllites* from *Gaudryceras* and *Tetragonites*.

Pseudophyllites indra Forbes. (Plate 20, fig. 1; Plate 29, figs. 3, 4, 5.)

Compare—

1846. *Ammonites indra* Forbes (1, p. 105, pl. 11, fig. 7).
1846. *Ammonites garuda* Forbes (1, p. 102, pl. 7, fig. 1).
1865. *Ammnoites indra* Forbes, in Stol. (11, p. 112, pl. 58, fig. 2).
1865. *Ammonites garuda* Forbes, in Stol. (11, p. 149, pl. 74, fig. 5).
1879. *Ammonites indra* Forbes, in Whiteaves (8, p. 105, pl. 13, fig. 2).
1895. *Lytoceras* (*Pseudophyllites*) *indra* Forbes, in Koss. (28, p. 137, pl. 16, figs. 6, 9; pl. 17, figs. 6, 7; pl. 18, fig. 3).
1895. *Phylloceras indra* Forbes, in Whiteaves (27, p. 129).
1903. *Pseudophyllites indra* Forbes, in Whiteaves (34, p. 331).
1906. *Lytoceras indra* Forbes, in Boule and Thevenin (42, p. 44, pl. 1, fig 1).
1906. *Pseudophyllites indra* Forbes, in Woods (40, p. 334, pl. 41, fig. 6).
1909. *Pseudophyllites indra* Forbes, in Kilian and Reboul (46, p. 14).
1920. ? *Tetragonites teres* van Hoepen (51, p. 144, pl. 25, figs. 1, 2).
1921. *Tetragonites* (?) sp. indef. Spath (59, p. 42, pl. 7, fig. 3).
1921. ? *Tetragonites virgulatus* van Hoepen (52, p. 11, pl. 3, fig. 1, 2; text-fig. 7).

Dimensions:—

	A.		B.		C.		D.	
Diameter	34	100	28	100	24	100	21	100
Height of last whorl	16	47	14	50	12	50	10	48
Width of last whorl	17·5	51	16	57	13	54	11	52
Umbilicus	8	24	6	21	5·5	23	5	24

	E.		F.		G.		H.		K.	
Diameter	21	100	113	100	20	100	27	100	33·5	100
Height of last whorl ..	10	48	61	54	9·5	47	12	44	16·7	50
Width of last whorl ..	12	57	51	45	9	45	12	44	17·1	51
Umbilicus	5	24	18	15	4·8	24	6	22	7·3	22

A, B, *Pseudophyllites indra* Forbes, Batley, Kaipara Harbour, N.Z.; C, D, E, *Pseudophyllites indra* Forbes, Bull's Point, Kaipara Harbour, N.Z.; F, G, H, *Pseudophyllites indra* Forbes, in Kossmat (28, p. 164); K, *Tetragonites virgulatus* van Hoepen (52, p. 13).

Shell discoidal, but whorls rapidly increasing with an involution of three-quarters. Whorls slightly wider than high in all measured specimens. In this respect the New Zealand specimens differ slightly from the Indian shells that were measured by Kossmat. Umbilical wall steep, and passing into the slightly flattened flank with a broad curve. There is, however, no suggestion of the angle at top of umbilical wall that is characteristic of *Tetragonites epigonus* Koss. Umbilicus narrow and deep, showing four

whorls when diameter is 12 mm. Surface of shell apparently smooth and polished, but when viewed with a lens it is seen to be much striated. The striae start nearly radially at bottom of umbilicus, but curve strongly forward, the curve beginning to decrease at top of umbilical wall, and at top of flank it passes into a faint backward curve precisely as shown by Kossmat (28, Taf. 18, fig. 3). The larger rounded bands to which Kossmat refers are also clearly visible, but they are not prominent, and are somewhat variable in importance. There are no constrictions.

Suture-line is much divided—the median saddle is rather long and has several jags on the side. External saddle unsymmetrically bifid, with the interior portion much smaller than exterior. First lateral saddle also bifid, but exterior portion is here the smaller, and the larger interior portion is divided by a secondary lobe almost as deeply as the main division of saddle, thus giving almost the appearance of a trifid form. Second lateral saddle small, and only three auxiliary saddles can be seen (Kossmat shows four in the Indian examples). External lobe as deep as first lateral, which is very wide and has a prominent secondary saddle in the middle. Auxiliary elements are moderately inclined, and umbilical lobe is not so deep as in most species of *Gaudryceras*. Internal portion of suture-line can be seen in one of the specimens, but it is a little eroded. Two high saddles not much divided, and the one near umbilical surface is considerably shorter than the other. It is therefore not very different from that of *Tetragonites simplex*, and of *T. epigonum* as drawn by Kossmat.

The form and ornamentation are so similar to those of the typical Indian examples which I had the opportunity of examining at the British Museum that I do not feel justified in separating it, notwithstanding the slight but constant differences in dimensions. A single example of *P. indra* was recorded by Kilian and Reboul in the collection from Seymour Island, and it has also been recorded from South Africa (Pondoland), and from the Nanaimo formation of Vancouver. In India it occurs in the Valudayur and Trigonoarca beds of the highest Senonian. It is considered by de Grossouvre that this species is the same as *G. colloti* from the Upper Campanian of the south-east of France; but Kossmat points out that, though the ornamentation and apparently the suture-line are closely similar, the dimensions of the European form are different, and he therefore retains this species as distinct. Kossmat also points out that it is closely related to *G. postremus* Redtenbacher from the Gosau. Spath classes van Hoepen's two species *Tetragonites teres* and *T. virgulatus* from Pondoland with this species.

Numerous examples have been found, especially at Bull's Point, also at Batley, and one at Whangaroa. Ferrar has found examples at Te Opu, in the Kaipara Harbour, as well as at Matakohe, on the shores of the harbour six miles north of Bull's Point. A specimen was sent to Professor Kilian, and was identified by him as *Pseudophyllites indra*.

Pseudophyllites whangaroaensis n. sp. (Plate 20, fig. 2; Plate 21, fig. 11; Plate 32, figs. 5, 6.)

Compare with the species quoted under *P. indra* Forbes.

Dimensions :—

	A.	
Diameter	42	100
Height of last whorl	21	50
Width of last whorl	22	53
Umbilicus	11	26

A, *Pseudophyllites whangaroaensis* n. sp., Whangaroa Harbour, N.Z.

Shell of moderate size, with whorls rapidly increasing in size. Involution almost one-half, with umbilicus narrow and deep. Whorls rise steeply from umbilicus and curve quickly into an inclined but somewhat flattened flank, which in turn leads to a rather flattened periphery. Four whorls at a diameter of 42 mm., but depth of umbilicus makes it almost impossible to expose them. The surface shows fine hair-like ribs, which at the bottom of umbilicus are almost radial; but they bend strongly forward and on flanks become more irregular and discontinuous. They are crossed by a series of low rounded spiral elevations, which are intersected by similar but more irregular radial elevations. These give rise to a check pattern, which is best shown near periphery. With a lens the fine hair-like striae can be seen crossing this checkwork, but they are too fine to show in a photograph. No constrictions can be seen.

The suture-line, which is incompletely shown in the single specimen, is similar to that of *P. indra,* but is perhaps rather less deeply dissected. The elements of first lateral lobe are somewhat less developed, but the general nature of saddles and lobes is the same.

This species is rendered distinct by its ornamentation, which makes such a striking checkwork pattern on the shell. Kossmat, however, says of *Pseudophyllites indra* that lightly impressed spiral lines are almost always present, but not so markedly as Stoliczka represents them. I can find no mention of this in Stoliczka.* The statement seems to refer to fine lines rather than the rounded swellings that are so striking in this species. None of the specimens of the species here called *Pseudophyllites indra* Forbes shows any sign of fine spiral lines or of the sculpture described for this species.

A single specimen has been found at Whangaroa.

BACULITES Lamarck.

Straight forms, circular or oval in cross-section, smooth or ornamented.

Baculites rectus n. sp. (Plate 19, fig. 1; Plate 32, figs. 9, 10.)

Compare—

1856. *Baculites chicoensis* Trask, *Proc. Cal. Acad. Nat. Sci.*, p. 85, pl. 2, fig. 2.
1865. *Baculites chicoensis* Gabb (3, pl. 14, fig. 27*b*; pl. 17, figs. 27, 27*a*).
1907. *Baculites* cf. *anceps* Paulcke (42A, p. 10, pl. 16, figs. 6, 6*a*).
1917. *Baculites* sp. cf. *vagina* Forbes, in Woods (57, p. 36, pl. 20, figs. 5 *a–d*).

The largest fragment measures 135 mm. in length, and the diameters of its cross-section are 30 mm. and 22 mm. at anterior end, and 21 mm. and 17 mm. at posterior end. All except the anterior 38 mm. is septate.

Ornamentation: Surface of shell quite smooth except for some obscure and indefinite growth-lines, and there are no signs of tubercles. Cross-section oval, and the siphuncle is situated at the more pointed end, which is not carinate. Chambers unusually long. First lateral lobe has a prominent projection which makes a distinct bifid division of the lobe. In second lateral lobe are three projections of practically the same size and shape, and the two divisions on either side of median projection are quite similar in development. Saddles deeply bifid. The only species that

* I find this is mentioned under the species *Ps. garuda,* which Kossmat regards as a synonoym of *Ps. indra* (11, p. 149, pl. 74, figs. 5, 5*a*).

approaches closely to the New Zealand species in characters of suture-line is *Baculites chicoensis* Trask from California. *Baculites ovatus* Say from North America, where it extends right through the Fort Pierre beds (Senonian) is also somewhat similar. The smooth surface as well as the suture-line distinguishes this species from all recorded from South Africa.

The species that occurs at Quiriquina, identified as *B. vagina* by Steinmann (26 p. 89, Taf. 6, figs. *a*–*e*, also text-figs. 8–12), is quite distinct from the New Zealand species both in external sculpture and in the form of the suture-line. The species recorded by Paulcke from South Patagonia (42A, p. 11, pl. 16, figs. 6, 6*a*) has much more sculpture, and lacks the most distinctive features of the suture-line. Kossmat states that a specimen from India is very similar to an unnamed specimen from California figured by Gabb (3, pl. 17, fig. 27), and names it *Baculites vagina* var. *simplex*. It, however, is quite different from the present species.

It thus appears that the present species, *B. rectus*, is more closely allied to *B. chicoensis* Trask than to any species of which descriptions are available. This species occurs in Queen Charlotte Sound of British Columbia, as well as in California, where in the type locality it is found only in the upper division of the Chico, though it has been recorded also in the Lower Chico of San Diego and Silverado (33, p. 27).

Baculites cf. *vagina* Woods (57, p. 36, pl. 20, fig. 5), which was found at the Amuri Point, in the South Island of New Zealand, almost certainly belongs to this species.

A large number of specimens has been found, though most of them are small fragments. They are most frequent at Bull's Point, though not uncommon at Batley and Whangaroa.

DIPLOMOCERAS Hyatt.

The Indian species *Diplomoceras rugatum* Forbes, to which the following New Zealand species is closely allied, was originally included by Forbes (1, p. 117) in the genus *Hamites*, but Stoliczka in 1885 used the generic name *Anisoceras* for this and a large number of related species. Kossmat in 1895 employed the generic title *Hamites* (*Anisoceras*). Hyatt in 1900 gave the generic name *Diplomoceras* to a number of the Upper Cretaceous uncoiled *Ammonites*, using as the genotype *D. cylindraceum* Defr. I am unable to obtain a full description of this genotype, but figures are given in Zittel (30A, p. 571, fig. 1187), and the same appear in the next edition, where the Ammonite section is edited by J. P. Smith (47A, p. 654, fig. 1259). The genus *Diplomoceras* is provisionally adopted for the single New Zealand species, though the suture-line has a very deep external lobe.

Diplomoceras wakanene n. sp. (Plate 19, fig. 3; Plate 31, figs. 8, 9.)

Compare—

1895. *Diplomoceras indicum* Forbes, in Koss. (28, p. 145, Taf. 19, figs. 4 *a*–*c*).
1895. *Diplomoceras subcompressum* Forbes, in Koss. (28, p. 145, Taf. 19, figs. 10 *a*–*b*, 11 *a*, *b*, 12).
1895. *Diplomoceras rugatum* Forbes, in Koss. (28, p. 146, pl. 19, figs. 7 *a*, *b*, 8 *a*, *b*, 9): on the pages quoted full references will be found to the work of Forbes and Stoliczka on these species.

Dimensions: Height of whorl, 11·2 mm.; width, 9 mm.: also, height, 7 mm.; width, 5·5 mm.

Shell nearly elliptical in cross-section; found in widely-curved fragments without any straight portions, which are apparently derived from an irregular spiral shell. Numerous rounded ribs of moderate size extend right round whorl, but they are most prominent on middle of flank and decrease greatly in size as they approach ventral and dorsal surface. No interstitial ribs and no unequal spacing to suggest that constrictions occur. No tubercles. Suture-line generally resembles that of *D. rugatum* more closely than that of any other Indian species, which are mainly distinguished by the size of second lateral saddles, whose greatest development is in *D. rugatum*. In the present species second lateral saddles are still larger, and are separated by a lobe as deep as first lateral lobe. External lobe also of much the same depth. First lateral lobe has the peculiarity of showing two prominent projections, of which the internal is the more pronounced. This feature is seen in *D. cylindraceum* Defr. (47A, fig. 1259; 45, Taf. 45, fig. 47), but not in any of the Indian species, *D. indicum* *D. rugatum*, *D. subcompressum*, as figured by Kossmat (28, Taf, 19). In the present species, however, both the external and the antisiphonal lobes are of unusual width and depth. First lateral lobe has a very similar structure in *Zelandites kaiparaensis* (Plate 31, fig. 2).

As indicated, this species seems to be closest to *D. rugatum* Forbes from the Valudayur beds of Pondicherry, but is distinguished by the rounded form of the ribs, absence of constrictions, as well as the form of suture-line. Kossmat states that *D. rugatum* is very similar to *D. cylindraceum* Defr. from the highest Senonian of Europe.

A single specimen has been found on the south-west side of Bull's Point, on the Kaipara Harbour, N.Z.

The specific name is that of a well-known Maori chief.

Oxybeloceras Hyatt.

Oxybeloceras sp. (Plate 15.)

Shell nearly straight, with a maximum width of 35 mm., thickness of 16 mm., and length of 292 mm. Surface marked with numerous ribs 4 mm. apart and strongly inclined. On each rib is a small bead-like tubercle on the side of the specimen that is preserved, and there is an indication of another small tubercle near periphery, but the condition of the specimen does not allow this to be seen distinctly. Unfortunately no indication of any suture-line is to be seen, and the only specimen seems to have been a body-chamber only. Costation quite distinct from *Anisoceras* sp. in Woods (57, p. 35, pl. 20, figs. 3, 4). The species of *Anisoceras notabile* and *A. obstrictum* figured by Killian and Reboul (46, p. 15, 16) have not inclined costation, and apparently no tubercles.

The present specimen is unfortunately far too imperfect for any specific description. There is a single specimen from the Mangamuka River, Hokianga, in the Auckland Museum. I am indebted to Dr. F. L. Spath for kindly informing me that this species probably belongs to the genus *Oxybeloceras* of Hyatt. I have not been able to find any statement of the characteristics of this genus, but Spath refers a Pondoland species to it (59, p. 50.)

Ptychoceras d'Orbigny.

Uncoiled forms, for the most part straight, but at intervals bent through 180°

Ptychoceras zelandicum n. sp. (Plate 19, fig. 2; Plate 32, figs. 11, 12.)

Compare—

1845. *Ptychoceras sipho* Forbes (1, p. 118, pl. 11, fig. 5).
1865. *Ptychoceras sipho* Stol. (11, p. 194, pl. 90, figs. 5–9).
1895. *Ptychoceras sipho* Koss. (28, p. 150).

Straight fragments only have been found, but, as the matrix is extremely hard and the specimens fracture easily, it is possible that the species has actually a hooked form, as it usual in this genus. Nearly all the fragments are small, 1–5 mm. in diameter, but there is one piece of a living-chamber 72 mm. in length and 16 mm. in diameter. Cross-section is almost circular, the taper is hardly noticeable, and thus the specimens have a cylindrical appearance. There are deep constrictions at intervals, strongly inclined to the axis. Anterior apex of constriction is at siphuncular side, and in quite small specimens is 4 mm. in advance of posterior portion. Surface of shell quite smooth, or feebly marked with indistinct lines following the general direction of constrictions. Suture-lines simple and symmetrical. Six prominent saddles and six lobes. Siphuncle situated at top of a small saddle in a deep lobe and the antisiphonal line is in a similar deep lobe, which divides the dorsal saddle into two divisions each as large as the other saddles. The six saddles are almost equal in size, and are broader than the lobes. Each saddle is bifid, and the two halves are rounded, and have a slight indentation in each half. The suture on the whole is similar to that of *Ptychoceras sipho* figured by Forbes (which figure is in the opinion of Kossmat much superior to Stoliczka's). Little distinction can be made between the different saddles in size or form, and the lobes also are almost indistinguishable from one another. The only distinction that can be made is that the external lobe is slightly wider than any of the others, and the median saddle is rather wider than the small saddles at the base of the other lobes.

This species is distinguished from *Ptychoceras sipho* by its simpler suture-line and by the apparently unhooked form. *Ptychoceras sipho* has not yet, so far as can be seen in the literature consulted, been compared with any other form. That species occurs in the Valudayur beds of Pondicherry (Upper Senonian).

A large number of fragments of this species has been obtained. It is very frequently found at Whangaroa, and specimens have also been found at Bull's Point and Batley.

ACANTHOCERAS Neumayr.

Kossmat, following Zittel, describes this genus as follows (28, p. 108): "Ribs simple or dichotomously split, straight, thickened in the outer portion; lateral and umbilical tubercles. External portion broad, with a median row of tubercles."

Group of *A. rotomagense*: Whorls broad, the ribs usually alternately long and short, with a straight radial arrangement, and seven rows of tubercles—siphonal, umbilical, and two marginal on each side, though either or both of the last may be obliterated. The suture-line has only two large saddles. The bifid external saddle is usually club-shaped. The second lateral saddle is on the umbilical slope and is not much larger than the auxiliaries, of which there are always a few present. The first lateral lobe is usually forked and is about as long as the external lobe. (A summarized translation).

Acanthoceras ultimum n. sp. (Plate 25, figs. 1, 1*a*; Plate 34, figs. 1, 2.)

Compare—

1894. *Acanthoceras newboldi* Koss., typical form (28, p. 5, pl. 12, figs. 2, 3) = *A. rotomagense* var. *asiatica* Jimbo (22, p. 177, Taf. 4, fig. 1).

Dimensions :—

	A.		B.		C.		D.	
Diameter	94	100	99	100	220	100	149	100
Height of last whorl	37	39	42	42	81	37	60	40
Width of last whorl	40	42	53	53	90	41	80	54
Umbilicus ..	27	29	32	32	76	35	50	34

A, *Acanthoceras ultimum* n. sp., Bull's Point, Kaipara Harbour, N.Z.; B, *Acanthoceras newboldi* var. *spinosa* Koss. (28, p. 7); C, *Acanthoceras newobldi* form. typ. Koss. (28, p. 5); D, *Acanthoceras rotomagense* var. *asiatica* Jimbo (22, p. 31) = *A. newboldi*, form. typ. Koss. (28, p. 5).

The table shows that in form this species is quite close to the typical *A. newboldi* Koss.

Shell of moderate size, discoid, but rather inflated; involution slightly less than one-half. Whorls wider than high. Umbilical wall steep, with widest part of shell just above top, and afterwards the slope towards periphery is gentle until the rounded angle on its edge. Periphery nearly flat. Whorls increasing rapidly in size. Ornamentation striking, but the only specimens are imperfect and fail to display it fully. Four constrictions on last whorl; they are narrow and extend right over periphery without a curve from bottom of umbilicus. Ribs on the two sides of constrictions have small tubercles. Nine tubercles on edge of umbilicus in last whorl. Most of these are large, vertical, and rounded, but a few are almost lamellar, following direction of ribs. Ribs large and conspicuous, rounded when shell is present but sharp and irregular when there is a cast. There are about nineteen on a half-revolution. Some start close to base of a tubercle, but there are also a few interstitial ribs. Half-way between umbilical edge and angle of periphery they rise into a low projection, and at the angle itself they form large projecting sharp tubercles which are much steeper behind than before. On siphuncular line are other lower tubercles which appear to be steeper before than behind. Ribs much flattened between edge of periphery and siphuncle. In the small inner whorls umbilical tubercles alone are present.

Suture-line is relatively simple, and the various arms of the saddles are not deeply intersected. Median saddle only slightly ornamented. Second lateral saddle rather distorted by development of the large umbilical tubercle. Auxiliary saddles are three in number, rapidly decreasing in size, but are not inclined so as to form a deep umbilical lobe. Internal portion of suture-line closely approaches that of *A. newboldi*, illustrated by Kossmat (28, pl. 3, fig. 2), though the smaller third saddle is less distinct. First lateral lobe indistinctly forked and rather shorter than external lobe. The suture-line generally much more finely divided than that of *A. newbold* and of the other Indian species figured by Kossmat.

This species is rather more tuberculate than Jimbo's form, which comes from the Ikushumbets. The dimensions show that it comes fairly close to the Indian species.

Only two specimens have been found, one of which is in extremely bad condition. Both of them were found at Bull's Point.

Kossmaticeras (de Grossouvre).

A number of species of ammonites that had been classed in the group Ligati by Stoliczka in 1885 (11) were in 1895 placed in the genus ***Holcodiscus***

by Kossmat (28). However, de Grossouvre pointed out in 1901 that these Upper Cretaceous forms were not cophyletic with the species of ***Holcodiscus*** from the Lower Cretaceous, and he then proposed the name ***Kossmaticeras*** for them. This name has subsequently been adopted by other authors.

Kilian and Reboul pointed out in 1909 (46) that great differences were displayed in the ornamentation of the species that were referred to the genus *Kossmaticeras*, and for the groups of these that appeared from their ornamentation to be related he suggested the following subgeneric names: *Gunnarites*, *Madrasites*, *Grossouvrites*, *Jacobites*, *Seymourites*, and *Grahamites*. This subgeneric classification has been adopted by other authors, and has been followed here, though the subgenera are treated as genera. It is also suggested that *Madrasites bhavani* var. *densicostata* Kilian and Reboul should be placed in a new genus *Maorites*, closely allied to the genus *Papapuzosia*.

GUNNARITES Kilian and Reboul, 1909.

Genotype: *Gunnarites antarcticus* Stuart Weller.

The group of *Gunnarites* was established by Kilian and Reboul (46, p. 26) in the following words: "Dans le groupe de *Kossmaticeras antarcticum* Stuart Weller les caractères se modifient par l'apparition de crénelures de plus en plus accentuées sur les côtes, et il finit par en rester, dans l'adulte, une ornamentation qui rapelle vraiment celle de certains *Douvilleiceras*. Ce sous-groupe, qui contient plusieurs espèces notamment *K. kalika* Stol., *K. antarcticum* Stuart Weller, peut-être désigné sous le nom de *Gunnarites*." In such descriptions from other countries as are available to me I can find no mention of other species that can be referred to this genus. It is therefore of some interest, and it must be regarded, so far as our present knowledge is concerned, as having its headquarters at Seymour Island. Its representation in New Zealand is, however, considerable, and one species is recorded from India. Possibly there is a species in Madagascar identified by Boule, Thevenin, and Lemoine as *K. theobaldianum* Stol. Stoliczka did not draw the suture-line of *G. kalika*, and Kossmat apparently did not see any specimens of that species. Kilian and Reboul (46) merely say of *G. antarcticus* that the suture-lines are imperfectly preserved, and of *G. nordenskjoldi* that it closely resembles that of *K. karapadense* figured by Kossmat (28, p. 41, Taf. 8, fig. 4c). It thus happens that the suture-lines in Plate 22 appear to be the first that have been drawn of species of this genus. It is well to make a comparison with those of *Madrasites*, of which there are abundant drawings by Kossmat, van Hoepen, Spath, and others, and as far as possible with those of other genera originally established by Kilian and Reboul as subgenera of *Kossmaticeras*. The specimen of *G. inflatus* from which the suture-line was taken has a whorl-height of 38 mm., that of *G. antarcticus* is 35 mm., and that of *G. zelandicus* 24 mm.

The median saddle has a considerable amount of frilling, especially near the top, but generally the suture-line is not finely divided. The external lobe has a strong projection in it which reaches nearly as high as the top of the median saddle. The external saddle is deeply bifid, with three well-developed arms on each side. The exterior half of the saddle is rather larger than the interior half. The first lateral lobe is a little deeper than the external lobe, and it is quite symmetrical. The first lateral saddle is not so deeply divided as the external saddle. The development of the second lateral saddle is much affected by the umbilical tubercle, over and around which its arms pass. In large specimens there may be

six auxiliary saddles, gradually decreasing in size and strongly inclined. The second lateral lobe is not nearly so deep as the external or the first lateral lobe.

The internal portion of the suture-line shows first a large, broad, and much-divided saddle, which is separated by a highly-divided lobe from a second high but narrower saddle, which is succeeded by a deep anti-siphonal lobe. It is thus very different from the internal portion of the suture-line of *Madrasites theobaldianus* Forbes, which is figured by Kossmat (28, pl. 7, fig. 5). This is the only drawing of the internal portion of a suture-line of any *Kossmaticeras* that I have been able to find. In this drawing there are three well-developed saddles and four auxiliary saddles in the internal suture-line. In general features the whole of the suture-line is not very different from that of *Madrasites*, though it is somewhat more frilled.

The suture-line of *Grossouvrites*—taking *G. gemmatus* as the genotype, as is done by Kilian and Reboul (46, p. 26)—is much more highly divided (46, p. 22, text-fig. 15). It has a great similarity to that of *Pachydiscus*, as remarked by other authors, and I am inclined to think that it should be placed in that genus. This species has been recorded from New Zealand by Trechmann (56).

One species of *Gunnarites* has already been recorded from New Zealand under the name *Kossmaticeras zelandicum* by Marshall (49, p. 444, pl. 33, fig. 2, text-fig. 2).

Gunnarites inflatus Kilian and Reboul. (Plate 22, figs. 1, 1*a*, 1*b*; Plate 40, figs. 1, 2.)

Compare—

1909. *Kossmaticeras* (*Gunnarites*) *antarcticum* var. *inflatum* Kilian and Reboul (46, p. 33, pl. 10, fig. 1; pl. 11, fig. 1; pl. 16, fig. 1).

Dimensions:—

	A.		B.	
Diameter	130	100	108	100
Height of last whorl	54	45	50	46
Width of last whorl	52	40	46	42
Diameter of umbilicus	38	29	31	29

In the specimen B the succeeding whorls measure H. 20–25, W. 21–25: H. 13, W. 15; H. 7·5, W. 9, respectively. The height is thus seen to increase more rapidly than the width.

A, *Gunnarites inflatus*, Batley, Kaipara Harbour, N.Z.; B, *Gunnarites inflatus*, Bull's Point, Kaipara Harbour, N.Z.

The shell is of moderate size, discoid in shape, with a deep umbilicus. Involution nearly one-half. Width of whorls slightly less than height. Wall of umbilicus steep but not perpendicular. A sharp curve at top of umbilical wall. Flanks almost flat and a low curve over periphery. Ornamentation distinct. There are twenty-five strong ribs in a half-revolution. High tubercles situated at top of umbilical wall; they are sharp, slightly twisted, and bent a little backward. From each of the tubercles two ribs arise. An interstitial rib generally arises between each pair of ribs a little distance from umbilical angle. No additional ribs arise higher on flanks. Five constrictions can be distinguished in a revolution. All the ribs are distinctly denticulated. They have a slight backward bend at top of flank, and afterwards bend a little forward at periphery. The first two and a half whorls have tubercles but no ribs.

Suture-line not well preserved so far as the external saddle is concerned, but in general is not highly divided. Median saddle well ornamented at

top, and is rather more than half the height of external saddle. There is a strong process in external lobe. External saddle strongly bifid, and divisions are again nearly symmetrically bifid. First lateral lobe rather deeper than external lobe and quite symmetrical. First lateral saddle large and bifid. Second lateral lobe and second lateral saddle rather irregular because of umbilical tubercles situated there. Auxiliary saddles six in number, rapidly declining backwards, forming a deep umbilical lobe. In internal portion of suture-line is a deep antisiphuncular lobe. Two large much-divided saddles of nearly equal size between it and umbilical angle. These saddles are separated by a deep lobe which has several sharply-pointed processes at base. Outer side of exterior of the two saddles forms with auxiliary saddles a deep umbilical lobe. This internal portion of suture-line differs in a marked manner from that of *Madrasites theobaldianus* Stol. (28, pp. 36 143, pl. 7, fig. 5). This is the only figure of the internal portion of a suture-line of *Madrasites* or *Gunnarites* that is to be found in accessible literature. This difference alone would justify the separation of *Gunnarites* from *Madrasites*, though there is at present no certainty that the same feature occurs in the other species of *Gunnarites*.

This species was originally placed by Kilian and Reboul as a variety of *G. antarcticum* Stuart Weller (46, p. 33). Professor Kilian kindly identified a specimen as identical with those obtained from Seymour Island. The specimen is in good condition, and was found by Miss Linley at Batley. It is embedded in a hard sandstone, and part of the suture-line cannot be seen distinctly. Another specimen has since been found at Bull's Point, and fragments probably of this species at Whangaroa. Kilian and Reboul record it from the Snow Hill beds, correlating them with the Trichinopoly beds of India, which they consider the equivalent of the Santonian.

Gunnarites zelandicus Marshall. (Plate 22, fig. 2; Plate 39, figs. 1, 2.)

Compare—

1917. *Kossmaticeras zelandicum* Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 444.

This species has already been described and figured (49, p. 444, pl. 33, fig. 2, text-fig. 2), but the figures now given are more complete. The specimen there described was sent to Professor Kilian, and I am much indebted to him for the note that the species is distinct, but very close to *G. antarcticum* Stuart Weller, so abundant at Seymour Island. The following dimensions were not given in the original description, and must be added :—

Diameter	75	100
Height of last whorl	33	44
Width of last whorl	28	37
Diameter of umbilicus	24	32

The species is distinguished from *G. antarcticum* Stuart Weller by the following characters: Ribs much more numerous, as many as thirty-six in a half-revolution. The constrictions generally interfere with the development of a single ordinary rib. Ribs more strongly bent forward than in *G. antarcticum*. Umbilical knots much more numerous. Suture-line generally similar to that of *G. inflatum*, but the external saddle is rather less symmetrically divided than in that species owing to the greater development of the external portion. The less depth of second lateral lobe is also a more pronounced feature. The nature of the auxiliary lobes unfortunately cannot be seen, nor does any specimen show the internal portion of the suture-line.

No complete specimen has yet been found. The only specimen comes from Batley. The type is in the Otago Museum.

Gunnarites nordenskjoldi Kilian and Reboul. (Plate 21, fig. 8; Plate 36, fig. 6.)

Compare—

1909. *Kossmaticeras antarcticum* var. *nordenskjoldi* (46, p. 33, pl. 12, figs. 4, 5; pl. 14, fig. 2; pl. 15, fig. 3).

Dimensions:—

Diameter	12	100
Height of last whorl . ..	5	42
Width of last whorl . .	5·5	46
Umbilicus	3·75	31

The specimen measured is the only one in a good state of preservation, and is quite juvenile.

Shell discoid and involute: about one-third of whorl exposed in umbilicus. Whorls almost circular in form. Nine large tubercles in a revolution on the edge of umbilicus. From each of these three or four ribs take their origin, and usually two interstitial ribs arise between tubercles. All ribs very sharp, but diminish greatly in height towards periphery, and on periphery itself are seen with difficulty. Three constrictions in a revolution are distinct. They commence at the bottom of umbilicus and sweep over flank with a slight forward bend, which is much more pronounced on periphery. They cut off a single rib. Ribs inclined forward, but show no curve until periphery, when there is a strong forward curve. Ribs not denticulate in this young specimen.

Suture-line shows a median saddle about half the length of external saddle, which is relatively slender and not deeply bifid. Both lateral saddles are distinctly bifid, auxiliary saddles small, and the suture-line slopes rapidly backward so as to form a deep umbilical lobe. The external and first lateral lobes are of nearly the same depth, but second lateral lobe much shallower. Both lateral lobes are symmetrically bifid.

Professor Kilian was good enough to identify this specimen for me, and kindly sent me a cast of the Antarctic type for comparison. There appear to me to be some important differences. The ribs in the New Zealand specimen are sharper and are inclined farther forward. The umbilical tubercles also are far less numerous.

A single specimen of this species, found at Batley. Kilian and Reboul compare it to *Madrasites karapadensis* Koss., and remark that the suture-line is similar to that of *M. karapadensis* and *M. buddhaicus* Koss. Actually, as will be seen from the figures in this paper, there are not many features of distinction between the suture-lines of the various species of *Madrasites* and *Gunnarites*—at any rate, in the external portion.

Gunnarites antarcticus Stuart Weller. (Plate 22, fig. 3; Plate 39, figs. 3, 4.)

Compare—

1903. *Holcostephanus antarcticus* Stuart Weller (35, vol. 11, p. 4, pl. 2, figs. 1, 2).
1909. *Kossmaticeras (Gunnarites) antarcticum* Kilian and Reboul (46, p. 31).

Dimensions:—

	A.		B.		C.		D.	
Diameter ..	22	100	19	100	65	100	84	100
Height	10	44	8	42	26	40	33	42
Width	9	41	8	42	25	39	31	39
Umbilicus ..	7	32	6	32	23	35	29	31

A, B, D, *Gunnarites antarcticus* Stuart Weller, Bull's Point, Kaipara Harbour, N.Z.; C, *Gunnarites antarcticus*, a cast of No. 135, given to me by Professor Kilian.

This species has already been fully described by Kilian and Reboul (46, p. 31), but, as the publication is not easily obtainable in New Zealand, a short description based on the New Zealand specimens is given here.

Shell discoidal, and large when mature. Whorls increasing rather rapidly in size; three whorls in a diameter of 8 mm. Whorls well rounded, but rather higher than wide. Umbilicus of moderate size, with a steep but not vertical wall. Ribs strong; some of them begin a little above bottom of umbilical wall, and at the angle they form twisted knots or tubercles. At this point they bifurcate, and there is usually one interstitial rib between each pair of knots. Every second or third rib is at first strongly inclined forward, but it soon becomes straight. At edge of periphery there is again a slight bend forward, and periphery is passed in a slight forward curve. About twenty-six ribs in a half-revolution, all of them crenulated. Six constrictions in a revolution, bordered in front or behind by a stronger rib, which is toothed like the rest, not smooth as in *K. kalika*.

No drawing of the suture-line of *Gunnarites antarcticum* has yet been published. *Gunnarites kalika* (Stol., 11, p. 140, pl. 70, fig. 5) was represented by a single specimen, which did not show a suture-line; and the many specimens from Seymour Island did not provide Kilian and Reboul with satisfactory material.

The suture-line in general closely resembles that of *Madrasites*, and we have excellent figures of several species of these by Kossmat (28, p. 39, pl. 7, figs, 1*d*, 5). The suture-line (Plate 22, fig. 3) is not very complicated; the saddles are distinctly bifid, though external half is rather larger than internal. First lateral lobe not quite symmetrical. First lateral saddle also distinctly bifid and nearly symmetrical, and considerably smaller than external saddle. Unfortunately, the whole of suture-line of this species cannot be seen, and the number of the auxiliary saddles is not known.

Gunnarites antarcticum is clearly related to *G. kalika* from the Aryalur beds of India, which are not lower than Upper Senonian and perhaps of Campanian age. Kilian and Reboul also compare this species to *M. carlottense* Whiteaves, from the Senonian of Vancouver (7, pl. 6), but the resemblance to this species does not appear to me to be a close one. *Gunnarites kalika* differs from this species in having four ribs springing from each umbilical tubercle, while the ribs which border the constrictions are not toothed. Kilian and Reboul make another comparison with *Madrasites pachystoma* Kossmat (28, p. 39, pl. 7, fig. 1 *a–d*), but the ribs in that species are not crenulated.

I am very much indebted to Professor Kilian for giving me a cast of *Gunnarites antarcticum* from Seymour Island, and for being good enough to identify my specimens for me.

Only three specimens have been found, all of which were collected at Bull's Point, but recognizable fragments were found at Batley and Whangaroa.

MADRASITES Kilian and Reboul.

This was established by Kilian and Reboul in 1909 as a subgenus of *Kossmaticeras*, and was characterized by them in the following words (46, p. 25): "Un premier groupe comprend des formes, telles que *K. karapadense* Kossm. sp., *K. bhavani* Stol., *K. theobaldianum* Stol., qui conserve jusque dans l'adulte leur ornamentation caractéristique; nous designerons cette section sous le nom de *Madrasites*. Certaines formes, comme *K. aemilianum* Stol., prennent aussi, que l'a justement remarqué M. Kossmat, une ornamentation rappelant celle d'Astieria."

The New Zealand species that can be referred to *Madrasites* show no striking differences from these of South India which have been described and figured by Forbes, Stoliczka, and Kossmat. Several of them are clearly seen to be closely allied to Indian species, as will be stated in detail in the specific descriptions. It is interesting to find species that are considered to be closely allied to *M. mooraviatoorensis* Stol. and *M. buddhaicum* Kossmat in the same locality. These New Zealand species of *Madrasites* seem to be quite different from those described from Zululand and Pondoland by Spath (53, 54, 59), by van Hoepen from Pondoland (51, 52), from Japan by Yokoyama (17) and Jimbo (22), and, in my opinion, from those of Vancouver and of California. On the other hand, *Madrasites tenuistriatus* Pauleke from South Patagonia (36) is closely related to *M. sulcatum* n. sp., and at Seymour Island Kilian and Reboul recorded *M. karapadense* (46, p. 30).

Madrasites sulcatus n. sp. (Plate 38, figs. 1, 2.)

Dimensions :—

Diameter	33	100
Height of last whorl	13·5	43
Width of last whorl	12	36
Umbilicus	12	36

Shell discoidal and rather compressed. Whorls distinctly higher than wide. Involution about one-third. Umbilical slope very steep; the surface passes through 80° over a sharp curve. Lower half of flank slopes at first slightly outwards, then is almost flat, but soon slopes gently to periphery, over which it passes in a narrow curve.

There are three deep constrictions in a half-revolution, which always cut off three ribs. Each constriction has a prominent bolster on both sides. Ribs narrow and sharp, with wide interstices. They arise just above umbilical wall and hardly touch tubercles, which are numerous. There are forty-seven ribs in a half-revolution. Some of them begin quite close to an umbilical tubercle, but most of them originate rather higher on the flank and are almost straight. They do not fork, and are not tuberculate. Twelve umbilical tubercles in a half-revolution. Suture-line not sufficiently well shown to allow a satisfactory diagram to be drawn, but it can be seen that it does not differ very much from the other species of *Madrasites*.

This species differs from all other known species of *Madrasites*. The relatively narrow aperture, close but straight ribs, and numerous tubercles are distinctive.

A single specimen has been found at Bull's Point. It was sent to Professor Kilian for examination, and he kindly sent the following note: "A new variety of *Kossmaticeras nordenskjoldi* K. & R."

Madrasites multicostatus n. sp. (Plate 21, fig. 6; Plate 35, figs. 1, 2.)

Compare—

1897. *Holcodiscus buddhaicus* Kossmat (28, p. 42, pl. 8, figs. 3 *a*, *b*, *c*).
1897. *Holcodiscus karapadensis* Kossmat (28, p. 41, pl. 8, figs. 2, 4).

Dimensions :—

	A.		B.		C.		D.		E.	
Diameter	36	100	24·5	100	20	100	36	100	30	100
Height of last whorl	14·5	40	9·5	39	8	40	16	44	10·8	36
Width of last whorl	15·5	44	11	45	9	45	16·5	46	9·2	31
Umbilicus	13·5	37	9	37	8	35	11	31	11·5	38

A, B, C, *Madrasites multicostatus* from Bull's Point; D, *Holcodiseus buddhaicus* Koss; E, *Holcodiscus karapadensis* Koss

Shell moderate size with whorls that do not increase rapidly. Involution about one-third. Whorls rather wider than high, with a steep slope from umbilicus, then gradually curving to periphery, which is gently rounded.

Ornamentation: A row of nineteen or twenty tubercles, small and rounded, but varying considerably in size, situated at top of umbilical wall. From these arise a variable number of small rounded ribs, which follow a rather sinuous curve to periphery. At first they are directed slightly forwards, but after passing top of umbilical slope they bend backwards, and on edge of periphery they again bend forward and so continuing pass over periphery. Most of the ribs become quite indistinct in peripheral region. Interstitial ribs occasionally arise at various points. Here and there a number of fine striations can be seen parallel to the ribs. Sometimes striations occur on or between ribs, and sometimes they entirely displace them; in such cases they pass over periphery without interruption. Seven constrictions in last whorl. They arise from bottom of umbilicus and have a thick bolster on either side. They bend forward rather more than ribs, of which they intersect two or three. Constrictions form a conspicuous curve over siphuncle.

Suture-line quite typical of species of *Madrasites* so far as the main portion of it is concerned, but there is a sudden change of direction after second lateral saddle. The three auxiliary saddles are directed almost radially, and thus a most pronounced umbilical lobe is formed almost like that figured by Kossmat for *H. bhavani* (28, p. 38, pl. 8, fig. 5). In other respects, however, there is no resemblance between these two species.

Professor Kilian was good enough to examine the type of this species. In a note of a purely preliminary nature he classed it as *Kossmaticeras buddhaicum* n. var. *multicostatum*. I consider, however, that it is quite distinct from *M. buddhaicum*. The present species has a much higher whorl, and more distinct and fewer tubercles. Its ribs do not bifurcate nearly so frequently, and are more numerous—forty-two in place of thirty-one in a half-whorl. The ribs are more rounded and more often vanish on periphery. Suture-line is, of course, quite distinct from that of *M. buddhaicum*. Ribs in this species are not inclined forward as in *M. karapadensis*, and aperture is much wider. The constrictions are more numerous, being seven in number, compared with four in the Indian species. *M. buddhaicum*, which is probably the most closely allied species, is found in the middle horizon of the Trichinopoly group of the Indian occurrences.

Madrasites regularis n. sp. (Plate 21, fig. 7; Plate 35, figs. 3, 4.)

Dimensions:—

	A.		B.	
Diameter	30	100	24	100
Height of last whorl ..	10·25	34	9	37
Width of last whorl ..	12	40	10·25	43
Umbilicus	12	40	10	42

A and B, *Madrasites regularis*, Bull's Point, Kaipara Harbour, N.Z.

These dimensions differ slightly from those of *M. multicostatus*, immediately preceding.

The most notable features are that the height is small and the umbilicus wide. Shell of moderate size, discoidal. Whorls wider than high. Umbilical wall steep but sloping. Flanks sloping gently to periphery, which is well rounded. Involution about one-half. Whorls not increasing rapidly in height or width.

Ornamentation: Top of umbilical wall crowned with a row of fourteen to seventeen rounded tubercles. These are first noticed on second whorl at a diameter of 7 mm. From each of these tubercles rise two or three moderate rounded ribs, and usually two interstitial ribs begin at the same level in each interval. Ribs much narrower than intervening furrows, but height decreases slightly at periphery, which is crossed with a gentle forward curve. Four large and conspicuous constrictions in a revolution. They begin at bottom of umbilicus and are inclined forward more strongly than ribs, one or two of which they intercept. Constrictions bordered by a large bolster behind and a much smaller one before.

Suture-line in several features is not very different from that of *M. multicostatus*, but auxiliary saddles are less developed and umbilical lobe is not so conspicuous. Serrations of saddles more finely cut. External lobe wide and process at the bottom more developed. First lateral lobe extremely symmetrical.

This species is distinguished from *M. multicostatus* by the more regular umbilical tubercles, stronger and more continuous ribs, fewer constrictions, and much less pronounced forward curve of constrictions on periphery. When compared with the Indian species it is found that the shape of the whorl distinguishes it from *M. karapadensis* Kossm. (28, p. 41, pl. 8, fig. 4). Ribs more continuous, and have not the same strong forward bend at periphery as in the Indian species. Ribs not inclined forward so strongly as in *M. bhavani* (28, p. 41, pl. 8, fig. 4), which is probably different from *Ammonites bhavani* Stol. (11, p. 38, pl. 8, fig. 5). They are also less numerous, and the umbilical lobe is less pronounced. *M. buddhaicus* Koss. (28, p. 42, pl. 8, fig. 3) has less continuous ribs. Of the Indian forms this species resembles *M. mooraviatoorensis* Stol. most closely (11, p. 158, pl. 77, fig. 4), but the latter species has rather smaller tubercles, while its ribs are closer, the constrictions five to a whorl, and bent more strongly forward. Its suture-line is not dissimilar. This species is placed by Kossmat (28, p. 33) in his first division of *Holcodiscus*, which he says shows special relationship to the forms of this genus found in the chalk of Europe.

Three specimens have been found at Bull's Point and one at Whangaroa.

Madrasites fortior n. sp. (Plate 21, fig. 12; Plate 41, fig. 3.)

Dimensions:—

	A.	
Diameter..	13·5	100
Height of last whorl	5·5	41
Width of last whorl	6·4	47
Umbilicus	4	30

A, *Madrasites fortior*, Whangaroa Harbour, N.Z.

Shell of moderate size. Whorls nearly circular, increasing rapidly. Whorl rises rapidly from umbilicus and curves evenly into the rounded flank, which in its turn maintains the curve over periphery. Large and prominent smooth ribs, fifteen in a half-revolution, arise from tubercles at top of umbilical wall. Usually two arise from each tubercle, and there are rarely any interstitial ribs. They are inclined slightly forwards, and cross periphery with a slight curve and without any diminution in size. Seven constrictions in a revolution, and they have a stronger inclination than the ribs, but intersect only one of them. The bolster behind each rib is not larger than an ordinary rib. Constrictions cross ribs with a strong forward bow.

Suture-line not well seen; it is apparently of the typical *Madrasites* form, but less dissected than in the other species.

Only three specimens of this species have been found, two of them very small and immature. There is only one (imperfect) specimen of a mature form. Two come from Whangaroa, the third from Bull's Point.

Madrasites sp. (Plate 11, fig. 4.)

A fragment from Whangaroa in some respects resembles *M. cumshewensis*. No suture-line could be developed.

JACOBITES Kilian and Reboul, 1909.

Kilian and Reboul regarded this group of species as constituting a subgenus of *Kossmaticeras*, and gave the following diagnosis of it: "Dans la série des *Kossmaticeras anderssoni* K. et R. nous assistons à une importante et rapide modification dès le diametre de 38 mm.: les côtes, fines et flexueuses des tours internes grossissent, s'espacent et finissent par se résoudre en tubercles et épines latérales; des tubercles siphonaux et une carène apparaissent; ce type est assez analogue a celui que se trouve réalisé dans les Noumayria du Jurassique; cette curieuse section pourra porter le nom *Jacobites*" (46, p. 26). Up to the present time, unless the form known as *Acanthoceras rotalinus* Neum. be included, as Kilian and Reboul suggest, the group of *Jacobites* has not been found outside of Seymour Island. The authors did not give any diagram of the suture-line of *Jacobites*, but merely state that it was not clearly shown.

Professor Kilian was good enough to examine a few specimens from the present collection, and amongst them he recognized some specimens that were practically identical with *J. anderssoni* (55, pp. 175, 176). Since then I have obtained many additional specimens from Bull's Point, and one from Whangaroa, while Mr. J. A. Bartrum has given me a cast of a specimen from the entrance of the Wairua River, Hokianga.

The criteria that have been used for placing species in this genus are: The whorls have relatively flat flanks; ribs usually arise from umbilical tubercles and often bifurcate; irregularity in the ribs after a diameter of 60 mm. has been attained; the presence of spines on the flanks and the periphery.

I have obtained specimens of other species which I have no hesitation in placing in this genus, though in the one case the wider spacing of the ribs begins at a diameter of 40 mm. and in the other not before the diameter is 115 mm.

The species here called *J. angulare* is placed in this genus with some hesitation, because there is no sudden increase in the size of the ribs, though the increase in their development within the limits of a single revolution is considerable. There is a prominent angle on the edge of the periphery which almost has the dimensions of a spine, and there is also a small tubercle on the siphuncular line.

In general the suture-line differs but little from that of *Gunnarites*; in fact, Spath (54, p. 121) regards the genus *Jacobites* as a late Campanian development of the *sparsicosta* group of *Kossmaticeras*. The first lateral lobe is distinctly wanting in symmetry.

The affinity with *M. sparsicostatus* and *M. denisoni* mentioned by Kilian and Reboul does not seem to hold closely in these species.

Holcodiscus sp. described by Woods from Pondoland (46, p. 336, pl. 42, fig. 2) was compared by Kilian and Reboul to *J. anderssoni* (46, p. 35). Spath points out, however, that this species must be regarded as closely related to *Madrasites madrasinus* (54, p. 135).

Jacobites anderssoni Kilian and Reboul. (Plate 21, figs. 3, 3*a*; Plate 37, fig. 4.)

Compare—

1909. *Kossmaticeras (Jacobites) anderssoni* Kilian and Reboul (46, p. 35).

Several fragments that were sent to Professor Kilian were identified as belonging to this species.

Dimensions :—

	A.		B.	
Diameter	33	100	54	100
Height of last whorl	13	39	25	46
Width of last whorl	11	33	19	35
Umbilicus	9	27	16	29

A, *Jacobites anderssoni* K. & R., Bull's Point, Kaipara Harbour, N.Z.; B, *Jacobites anderssoni* K. & R. (46, p. 35), from measurement of cast kindly sent by Professor W. Kilian, No. 136.

Shell discoidal, with involution about one-half. Whorls higher than wide. Umbilical wall nearly vertical, with a sharply rounded angle to the flanks, which are nearly flat for about two-thirds of their height and then curve in an almost semicircular arc over periphery.

Ornamentation: Large number of tubercles at crest of umbilical wall. Numerous ribs arise from them at about one-third of the distance along the flank, and then pass over periphery with hardly any bend. Three constrictions in a revolution, bordered with a thick bolster before and behind; they are curved forward more sharply than ribs, two of which they intersect. Suture-line well shown. Median saddle slightly frilled. External saddle high and deeply bifid. First lateral saddle much smaller and second situated where tubercles arise at top of umbilical wall. Auxiliary saddles small and suture-line slopes back in umbilical region. External lobe not so deep as first lateral lobe. The latter is trifid but more developed on external side than on internal. Second lateral lobe about as deep as external lobe. Internal portion of suture-line has a deep antisiphuncular lobe and two high saddles separated by a lobe not so deep as the antisiphuncular lobe. Both saddles are bifid. Second saddle the wider, and on its external side are some projections that probably represent additional saddles. This internal portion of the lobe-line more closely resembles that of *Gunnarites* than that of *Madrasites*. It suggests an affinity with *Acanthoceras*.

From this description it will be seen that there is a considerable difference between this form and the mature form of *M. anderssoni* (46, p. 35). The whorl in the New Zealand form is not so high, and the number of umbilical tubercles is a good deal larger. The specimens are immature, and nothing can be said about costation of mature whorls, which is so striking a feature in Kilian and Reboul's specimens from Seymour Island. Kilian and Reboul do not give a figure of the suture-line of the species, but they state that there is a resemblance between this species and *K. pondicherrianum* Koss. and *K. sparsicostatum* Koss. (46, p. 36), and they state that the horizon is that of the Valudayur beds.

Jacobites angularis n. sp. (Plate 21, fig. 2; Plate 36, figs. 4, 5.)

Dimensions :—

	A.		B.	
Diameter	55	100	38	100
Height of last whorl	23	42	15	39
Width of last whorl	25	45	17	45
Umbilicus	17	31	12	31

A, B, *Jacobites angularis*, from Bull's Point, Kaipara Harbour, N.Z.

Shell of small or moderate size. Whorls rather wider than high, with a distinct angle on edge of periphery as well as one much less distinct half-way between edge of periphery and umbilicus. Involution rather less than one-third. Whorls increasing rather rapidly in size.

Ornamentation: A few large ribs arise at bottom of umbilicus, and when they reach top of umbilical slope they develop into prominent elevated tubercles from which arise three and sometimes four ribs. There are also one or two interstitial ribs which commence on edge of umbilical wall between tubercles. Ribs at first bend slightly forward, and this bend is maintained until they reach edge of periphery, where each of them swells into a low rounded tubercle and bends backwards so as to pass over periphery almost at right angles, or with a slight backward curve. Ribs do not decrease in peripheral region, and on siphuncular line swell into small rounded tubercles. None of the ribs are serrated. In young stage the ribs when well preserved are very sharp and are situated quite close together; but when older they become spaced out considerably. Constrictions are not conspicuous, and do not interefere with the regularity of the ribbing.

Suture-line: Median saddle a little frilled and external lobe is not particularly deep. External saddle rather high, narrow, and deeply bifid; its first large external arm is well over top of median saddle. First lateral lobe slightly deeper than external lobe, and, as in the other species of *Jacobites*, it is not quite regularly trifid, for the external projection at bottom of this lobe is rather larger than internal one. First lateral saddle a good deal smaller than external one, and second lateral is on edge of umbilicus and its development is rather affected by umbilical tubercle. Five auxiliary saddles are small, slope backwards, rapidly diminish, and form a distinct umbilical lobe. This species is distinguished by its relatively wide aperture, strong umbilical tubercles, and the regular rounded tubercles on each of the ribs. In the available literature I cannot find a description of any species that comes close to this one.

Three specimens found at Bull's Point.

Jacobites minimus n. sp. (Plate 21, fig. 5; Plate 38, figs. 3, 4.)

This small shell is probably immature, but the very marked sculpture characterizes it as a different species from any other in this collection.

Dimensions :—

	A.	
Diameter	8·75	100
Height of last whorl	4·1	47
Width of last whorl	3·75	43
Umbilicus	2	23

A, *Jacobites minimus*, Bull's Point, Kaipara Harbour, N.Z.

Whorls slightly compressed and strongly involute. Umbilical wall steep but not vertical. Widest part of whorl just above umbilicus, whence there is a gradual slope on flank towards periphery, on the edge of which is a rounded angle. Periphery gently rounded.

Ornamentation: On the edge of umbilicus are seven large tubercles in a whorl, from each of which two ribs arise, and there are two or four interstitial ribs in each interval. Seventeen ribs in a half-revolution. Ribs are rounded and at first bend slightly backward, but at a higher level on flank they take a gentle bend forward, and at edge of periphery there is a strong rounded tubercle on each rib. Across periphery the ribs run straight, and there is another rounded tubercle on median line. Between the tubercles the ribs are less elevated than on flanks. Suture-line shows five saddles, which gradually decrease in size from ventral surface to umilicus. The external and first lateral saddles are symmetrically bifid, and lobes trifid.

Lobes all of much the same depth, and suture-line bends backward to a considerable extent as it approaches umbilicus. On the whole, the suture-line has a close resemblance to that of a young specimen of *Gunnarites* (Plate 22, fig. 1*b*), but it is a good deal simpler, and more even

In the available literature I am unable to find any species that resembles this one closely. It is perhaps closer to *A. idoneus* Stol. than to any other, but differs from it in having umbilical tubercles and in the symmetrical development of the two sides.

The single specimen from Batley is probably immature, but is in such a good state of preservation and so distinct that it has been described as a new species.

Jacobites whangaroaensis n. sp. (Plate 21, fig. 1; Plate 37, fig. 1.)

Dimensions:

Diameter	147	100
Height of last whorl	63	43
Width of last whorl	56	38
Umbilicus	46	31

Involution about two-fifths. Whorls higher than wide. Umbilical wall steep but not vertical, rounded at angle. Whorl broadest at about one-third of its height above umbilical angle; thence it slopes gently to periphery, which is broad and well rounded.

Ornamentation: About ten large tubercles on edge of umbilicus; they are larger radially than longitudinally. Four ribs rise from each tubercle, and there is usually one interstitial rib between each pair of tubercles. Ribs close together and rounded on inner whorls, and more widely spaced on body-whorl, where at margin of periphery many of the ribs bifurcate and become extremely sharp and high and apparently spiny.

Suture-line only partially visible. Median saddle a little dissected on margin. External saddle high and deeply bifid, external half being slightly larger than internal half. First lateral lobe deeper than external lobe, and unequally trifid, for the external of the two major projections is rather larger than the internal one.

The species differs from *J. anderssoni* Kilian and Reboul in the sharpness of the ribs in the body-whorl and their regularity. They are also more closely spaced. There is no peripheral angle as in *J. angularis* n. sp.

A single specimen, found at Whangaroa.

Jacobites waitapuensis n. sp. (Plate 23, fig. 2; Plate 44, fig. 1; Plate 45, fig. 2.)

Dimensions:—

Diameter	100
Height of last whorl	40
Width of last whorl	31
Umbilicus	33

Aperture widely oval. Umbilical wall steep, with a rounded angle to the flank, which is moderately flat, though it has its widest part rather nearer umbilicus than middle of flank, which slopes uniformly and gently to the well-rounded periphery.

Ornamentation : Five constrictions in a whorl, each with a prominent bolster before and behind. They are first inclined slightly forward, but in middle of flank they become almost truly radial, soon taking a stronger bend forward and passing over periphery with a distinct forward loop. At top of umbilical wall there are prominent rather rounded tubercles, eighteen in a whorl. From each of these arise three or four ribs, though some of these arise from bottom of umbilicus. Ribs at first bend slightly forward but soon straighten up and pass straight across periphery. Each constriction cuts off three ribs on each side. There are in addition low rounded tubercles on margin of periphery, twenty-three in a revolution, but unfortunately these can hardly be seen in the photograph. Indistinct tubercles also occur on periphery.

Suture-line : Median saddle frilled to a considerable extent, much more than in the two previous species. External saddle deeply bifid, and the two portions are about as unequal as in other species of this genus. First lateral saddle relatively rather larger than in the three previous species. The development of second lateral saddle is affected by umbilical tubercles. Auxiliary saddles, as in the other species, are strongly inclined, forming a deep umbilical lobe. The internal suture-line, which, however, is not figured, is close to that of *J. angulare* in form.

I am unable to find any described species that approaches closely to this one. The tuberculate periphery and median line, as well as the suture-line, distinguish it at once from all species of *Kossmaticeras*. The same features, as well as the more rounded form and coarser ribs, enable it to be distinguished at once from *Maorites*. It certainly comes nearer to *Parapachydiscus* than the other species of the genus. The whorl, however, is rather narrow, the ornamentation is distinctive, and the first lateral saddle shows lack of symmetry. . .

A single specimen, in good condition, from Nedler's, at Whangaroa.

NEOMADRASITES.

Tubercles on shoulder and on median line. Suture-line resembles that of *Madrasites*.

Neomadrasites nodulosus n. sp. (Plate 21, figs. 4, 4*a* ; Plate 36, figs. 1–3.)

Dimensions :—

	A.		B.	
Diameter ..	29	100	20	100
Height of last whorl	11	35	7·5	37
Width of last whorl	13	45	9·25	46
Umbilicus	13	45	9	45

A, B, *Neomadrasites nodulosus*, from Bull's Point, Kaipara Harbour, N.Z.

Shell small, discoid. When the diameter is 29 mm. there are three whorls. Whorls decidedly wider than high, and increasing in width rather rapidly. Involution about one-half. Umbilical wall steep but rounding off into flanks that are gently inclined towards periphery, at edge of which there is a distinct angle, and periphery itself is gently rounded.

Ornamentation : At top of umbilical slope are a number of rounded tubercles, as many as seven in a half-revolution. Three or four sharp

but smooth ribs start from each tubercle, and there are two or three interstitial ribs between each pair of tubercles. Altogether forty ribs in a half-revolution. At edge of periphery ribs unite together in twos or threes into rounded tubercles situated irregularly with respect to umbilical tubercles, and here are also one or two interstitial ribs which do not touch tubercles. Ribs almost straight to edge of periphery, when they bend strongly forward and across it with a pronounced forward curve. At median line each rib has a small rounded projection or tubercle. On inner whorls the umbilical tubercles are well marked but the others are indistinct. In a half-revolution there are two constrictions with a prominent bolster on each side. These have the median projection, and they may join in the tubercles at edge of periphery.

Suture-line shows no striking features as compared with other related species of Kossmaticeratidae. Median saddle nearly simple, and external lobe not important. External saddle high and symmetrically bifid, as are lateral saddles, which rapidly decrease in size. First lateral lobe symmetrically trifid. At edge of umbilical wall suture-line bends sharply backwards and auxiliaries are directed almost internally. A similar sudden declension of suture-line is noticeable in *Madrasites multicostatus* (Plate 21, fig. 6) and in *Brahmaites brahma* (28, pl. 8, fig. 9). The internal portion of suture-line shows five saddles, which is quite distinct from that of *Madrasites* (28, pl. 7, fig. 5), and from that of *Jacobites anderssoni* (Plate 21, fig. 3*a*) as well as from *Gunnarites*.

A specimen sent to Professor Kilian was characterized by him as follows: "Il convient de signaler en outre une forme trés curieuse, que je rattache à *Jacobites*, et dont M. Marshall m'a soumis un fragment, qui présente une modification progressive de l'ornamentation (apparition outre la présence des tubercles ombilicaux, de tubercles réunissant deux côtés du côté externe des flancs, et en outre, indication d'une série des tubercles siphonaux moins accentués, mais très nets)." (55, p. 176.)

I have not adopted Professor Kilian's suggestion, because the development and drawing of the suture-line appears to me to indicate a closer relationship to *Madrasites* than to *Jacobites*. In its details, however, the ornamentation is distinct from both. I therefore suggest a new genus, *Neomadrasites*.

Several specimens, but none quite complete, have been found at Bull's Point.

BRAHMAITES Kossmat.

In the original diagnosis of this genus Kossmat says (28, p. 45) that it is very closely related to *Holcodiscus* (= *Kossmaticeras* Grossouvre). The most characteristic features are the presence of siphonal knots placed on ribs, the prominent bolsters bordering constrictions, and the highly variable nature of sculpture. In three specimens of middle age the flanks only are sculptured. At a later stage the ribs develop into high ridges which leap over periphery in a manner that is quite different from that of *Holcodiscus*.

The present species, *B. rotundus*, has the young form only, but the largest specimen shows a tendency towards the development of tubercles on the shoulder—a fact that definitely distinguishes it from *B. brahma* and the two other species *B. vishnu* and *B. haugi*.

So far as records go, the genus appears to be restricted to India. Some of the New Zealand specimens were sent to Professor Kilian, who was good enough to inform me that he agreed that they belonged to a new species of *Brahmaites* (55, p. 175).

Brahmaites rotundus n. sp. (Plate 21, fig. 9; Plate 31, figs. 4, 5.)

Dimensions:

	A.		B.		C.		D.		E.	
Diameter	19·75	100	16	100	12	100	11	100	88	100
Height of last whorl ..	7	35	5	31	4	33	3·8	36	25	28
Width of last whorl ..	8·75	44	7·50	46	7	58	6·5	60	38	43
Umbilicus	7	35	5·75	36	4·75	39	4	39	42	48

A, B, C, D, *Brahmaites rotundus*, all from Bull's Point, Kaipara Harbour, N.Z.: E, *Brahmaites brahma* Forbes, in Koss. (28, p. 45).

The whorl is clearly much wider and the umbilicus narrower than in *Brahmites brahma.*

Shell small, whorls much wider than high, especially in the younger specimens. Involution about one-quarter, and umbilicus deep. Wall of umbilicus steep but not vertical. Flank sharply rounded; periphery wide, with gentle curve.

Ornamentation: About eleven rounded tubercles in a revolution, situated on edge of flank near but not on edge of umbilicus. Usually three ribs start from each knob, and there are other interstitial ribs which start on side of umbilical wall. Ribs rather sharp, and separated by considerable intervals. At first they bend a little forward: the curve is soon increased, and near periphery it is strong, though the ribs themselves become less distinct. They cross periphery with a strong bow forward. Two or three deep constrictions in a revolution, bordered behind by a thick bolster. They have exactly the same forward inclination as the ribs, with which they do not interfere. Occasionally there is a slight suggestion of the presence of tubercles on edge of periphery, as in *Neomadrasites nodulosus*, but the ribs are not affected, and there is no indication of median tubercles on periphery, except that the bolster behind each constriction is swollen on the median line, as is also the case in *B. brahma.*

Suture-line was drawn from a very small specimen, but it is clear in all the specimens that the first lateral lobe is unsymmetrical. The irregular trilobed nature is due to the larger development of external than internal projection in this lobe. Suture-line does not show such a sudden backward curve in the region of auxiliary saddles as is seen in so many of the related species of *Madrasites*. This asymmetry of the first lateral lobe is not, however, noticeable in *B. brahma.* Internal portion of suture-line is more like that of *B. brahma* (28, pl. 8, fig. 9).

This species is not very different from *B. brahma* (28, p. 45, figs. 7–9), especially in the form of aperture and in ornamentation, though ribs are rather closer together. Its form is rather more rounded and suture-line is less divided.

Several specimens have been obtained from Batley and Bull's Point, but none at Whangaroa. This species is commonest at the first locality.

MAORITES n. gen.

Genotype: *Maorites tenuicostatus* Marshall.

This genus is suggested for species that have the general form of *Puzosia* or *Parapuzosia* but possess umbilical tubercles—at any rate, in the young form. The suture-line is typically of the Puzosid type, though usually more highly developed than in the known genera of that group.

The general form has a highly involute whorl with flat flanks, the widest part of which is just above the steep umbilical slope. Ornamented with a number of ribs, usually quite fine. These at first are directed forward,

but on the flanks they become radial and cross periphery at right angles. About five constrictions more or less decidedly marked in a revolution. Many of the ribs arise from well-marked tubercles on edge of umbilicus, but there are always several interstitial ribs as well.

Suture-line: Median saddle a good deal frilled, and external lobe wide and deep. First lateral lobe has a highly important development. It is a good deal deeper than external lobe, and also is very wide. It is unsymmetrically bifid owing to the unequal development of the elements in lobe, those on external side being much larger and stronger than those on internal side. Second lateral lobe also unsymmetrical. Five or six auxiliary lobes are present and strongly inclined outwards. External saddle bifid, but with a much stronger development on external than on internal side. First lateral saddle also bifid, and in this case internal portion of saddle is a good deal larger than external. Second lateral saddle much smaller, and sometimes a little distorted by the tubercles, for it is situated on edge of umbilicus. Five or six auxiliary saddles quite small, and strongly inclined.

It is noticeable that Stoliczka placed his species *Ammonites madrasinus*, *A. kandi*, *A. aemilianus*, *A. bhavani*, and *A. kalika* in close proximity to *Ammonites bhima*, *A. planulatus*, &c., as though he thought that there were affinities between them. The last two of these species were afterwards classed by Kossmat in the genus *Puzosia*. On the other hand, *Ammonites pacificus*, *A. papillatus*, *A. mooraviatoorensis* were by Stoliczka far removed from those first named, though both groups were placed in the large and comprehensive class of *Ligati* (11, App. 6, 7). Kossmat, on the other hand, subsequently placed both of these groups (*A. madrasinus* and *A. pacificus*) in the genus *Holcodiscus*, but, of course, excluded *A. bhima* and *A. planulatus*. It seems, however, that Kossmat did not have the opportunity of examining any of Stoliczka's specimens of the first group, but he saw one specimen of *A. aemilianus* in the museum at Vienna. Kossmat also had ten specimens that he ascribed to Stoliczka's species *A. bhavani* in the Warth collection, which was the one that provided most of the specimens that he studied. It is also noticeable that Stoliczka's drawings of the suture-lines of the species in the *A. madrasinus* group, though always somewhat sketchy, are in some respects distinctly different from those in the second, or *A. pacificus*, group, now mainly classed by Kilian and Reboul as *Madrasites*. (Compare 11, pl. 69, fig. 7, and pl. 70, figs. 3, 8, with pl. 77, figs. 5, 8, 9*b*, &c.). The suture-lines in the former are more divided, and they have dissymmetry in the first lateral lobe. In addition, the first lateral lobe is very deep. In the second, or *A. pacificus*, group, on the other hand, the suture-line is far less finely divided; there is almost complete symmetry in the first lateral lobe, which is relatively less important and either not deeper or very little deeper than the ventral lobe. The descent to the umbilical lobe is also far less regular in this second group. The shells of the first group also in most cases show a definite tuberculate character in the umbilical region, which is generally absent in the second group—that is, the ribs more decidedly and definitely arise from somewhat lamellar tubercles, which may be absent in the adult stage. The tubercles in the second group are much more rounded in their form.

The genus *Maorites* agrees with the species of the first group in the majority of their characters, and it is here suggested that the species *Ammonites kandi*, *A. aemilianus*, and *A. madrasinus* of Stoliczka should be placed in this genus, though this point cannot be definitely settled until

the types of the Indian species which were described by Stoliczka are re-examined and their suture-lines have been carefully drawn.

In regard to *Ammonites bhavani* there is considerable difficulty. It is a form without any striking specific characters in its ornamentation; and in the absence of well-drawn suture-lines of Stoliczka's specimens it is hard to be certain whether a species in another collection is correctly identified with it. If Kossmat's specimens do belong to the true *A. bhavani* of Stoliczka there is no doubt that the species is correctly placed in the second group referred to above (the *A. pacificus* group). This has been done by Kossmat, and Kilian and Reboul have subsequently placed it in their subgenus *Madrasites*. On the other hand, Stoliczka's classification leads to the idea that his *A. bhavani* should be placed in the first of the two groups—that is, the group of *Ammonites madrasinus*. In order to make this point clear, a table is given in which the relative dimensions of Stoliczka's specimens of *Madrasites bhavani* are given as well as those of Kossmat, and also two of Kilian and Reboul's specimens of *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostata*, the last measurements being obtained from the casts that were kindly forwarded to me by Professor Kilian.

	A.		B.		C.		D.		E.		F.	
Diameter	38	100	65	100	36	100	66	100	63	100	125	100
Height of last whorl ..		37		41	15	42	26	40	30	47	51	40
Width of last whorl ..		32		31	14·5	40	24	36	18	29	31	25
Umbilicus		24		26	11	30	22	33	13	21	31	25

A, B, *Ammonites bhavani* Stol. (11, p. 138); C, D, *Holcodiscus bhavani* Koss. (28, p. 145); E, F, *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostatum* Kilian and Reboul (46, pl. 15, fig. 4; pl. 18, fig. 1).

These dimensions show that Kossmat's specimens are distinctly wider than the original ones of Stoliczka, and have a wider umbilicus, while Kilian and Reboul's specimens have a slightly narrower whorl.

Ammonites kalika appears to me to belong to a different group. It is the only Indian species of this nature that shows denticulations on the ribs; and it should almost certainly be classed with the species of *Gunnarites* described in the present collection. Stoliczka gives no drawing of the suture-line of this species, and Kossmat apparently saw no specimen of it. Those obtained in the present collection show that the species of *Gunnarites* are closely related to *Madrasites*, though the internal portion of the suture-line shows important differences if Kossmat's drawing of *M. theobaldianus* is taken as type. The New Zealand species *M. regularis*, however, shows a similarity to *Gunnarites*. The large and important collection of Antarctic species from Seymour Island described by Kilian and Reboul were in too bad a condition to allow the suture-lines to be traced.

The affinities of *Maorites* and its genealogy are a little hard to decide. As stated more fully subsequently, the author, in spite of the great weight of authority in favour of regarding *Puzosia* and *Parapuzosia* as derived from the Desmoceratidae, is himself of opinion that they are an independent branch derived from a Hoplitid ancestry. In connection with this it is important to recall the words of Sarasin, who wrote as follows (29A, p. 799): "*Puzosia* est du reste derivée directement de *Desmoceras* . . . Quant a l'origine de *Desmoceras* . . . il se rapproche nettement de *Hoplites* et il est a mon avis incontestablement derivée de *Hoplites* ou tout au moins de *Perisphinctes*."

Djanélidze in 1922 established *Dalmasiceras*, a new subgenus of *Hoplites*, from the Upper Tithonian of France (60, p. 256). The species of *Dalmasiceras* described by him differ so much in appearance and ornamentation from the typical *Hoplites* that doubt might well be entertained as to the real position of the genus. However, Djanélidze says, "Remarquons d'abord que *Dalmasiceras* est sans conteste une branche specialisée de *Hoplites*." The forms of *Maorites* and of *Puzosia* are extremely similar to that of *Dalmasiceras*, and the same is equally true of the general features of the suture-line of these genera, both in its external and internal portions. There is, however, a difference in sculpture. Apart from the tuberculate nature of the ornamentation of the typical *Hoplites*, which is not developed to any extent in these genera, there is the marked break of the costation at the periphery. This feature, however, is not constant even in *Hoplites* itself, for Hyatt remarks that in the young forms the costation is sometimes continuous across the periphery (47A, p. 668). In addition, it is noticeable that *Sonneratia*, a genus included by Hyatt in the Hoplitidae, has continuous ribs across the periphery, and it therefore seems that this feature of ornamentation should not be emphasized too much. *Maorites* appears to be closer to the Hoplitid stock through *Dalmasiceras* than does *Puzosia*. In the suture-line the great depth and width of the external lobe, the depth of the first lateral lobe, and its asymmetry are more strongly marked than in *Puzosia*, and make a close approach to the conditions of the suture-line of *Dalmasiceras*, though they are more marked than in that genus. Tuberculation on the edge of the umbilicus also is present in *Maorites*, though absent in *Puzosia*. It is, however, to be noted that both Jacob and Nowak ascribe asymmetry to the flattening of the flank. This does not appear to hold in the New Zealand species; for, *e.g.*, *M. tenuicostatus*, which is relatively rounded, has far more marked asymmetry than *Puzosia angusta* which has an extremely narrow form.

The first specimen of this genus that was found was classed by me under the name *Kossmaticeras tenuicostatum* (49, p. 445). This specimen was afterwards taken to Europe, and Professor Kilian was good enough to examine it. He classed it with his *Madrasites densicostata* from Seymour Island (55, p. 175). When the suture-line was developed and drawn, it at once became clear that the specimen could not belong to either *Kossmaticeras* or *Madrasites*, and that, on the other hand, it possessed close affinities with *Puzosia*. Professor Kilian, with the greatest kindness, sent me a cast of two specimens of his *Madrasites bhavani* var. *densicostata*, and inspection of these showed that in all probability this species belonged to the same genus as the New Zealand species. The condition of the Seymour Island specimens was, however, so bad that Professor Kilian was not able to develop the suture-lines. I have already stated that in my opinion some of the Indian species described first by Stoliczka, and afterwards placed by Kossmat in the genus *Holcodiscus*, and later in *Kossmaticeras* (*Madrasites*) by Kilian and Reboul, especially *K. madrasinum*, *K. kandi*, and *K. aemilianum*, may also possibly belong to this genus.

The characters of the genus *Maorites* may be summarized as follows: Form somewhat compressed and resembling that of *Puzosia*. Ornamentation shows umbilical tubercles a little extended radially. Ribs generally rather fine and sinuous, but continuous across periphery, which they cross without a forward bend. Constrictions deep and with a strong forward inclination. Suture-line in general resembles that of *Puzosia*, but the first lateral lobe is a little deeper and the external lobe is wide. The unsymmetrical development of the first lateral lobe is marked. The suture-line is greatly dissected.

Maorites tenuicostatus Marshall. (Plate 23, figs. 1, 1*a*; Plate 42, figs. 1, 2; Plate 45, fig. 1.)

Compare :—

1917. *Kossmaticeras tenuicostatum* Marshall (49, p. 445, pl. 33, fig. 1).

Dimensions :—

	A.		B.		C.		D.	
Diameter	142	100	143	100	20	100	63	100
Height of last whorl	60	42	60	42	9	45	30	47
Width of last whorl	43	30	43·5	31	7	35	18	29
Umbilicus	35	24	35	24	5	25	13	21

A, B, C, *Maorites tenuicostatus* Marshall, Batley, Kaipara Harbour, N.Z.; D, *Kossmaticeras bhavani* var. *densicostatum* K. & R. (measurements from a cast).

Shell large, discoid. Involution rather more than one-half. A steep rounded slope, nearly vertical in young forms, rises from umbilicus, and greatest width of whorl is attained just above umbilical slope. Flanks nearly flat but with a gently increasing slope towards periphery. Edge of periphery well rounded, and a well-rounded curve over periphery.

Ornamentation: In mature form constrictions not distinct, and in no way interfere with costation, for they have the same slope as ribs. A large number of narrow rounded ribs, which in mature form are almost constant in size, from bottom of umbilicus to periphery. In younger forms ribs do not all extend to bottom of umbilicus, and on its margin about every fifth rib is swollen and almost forms a small tubercle extended in a radial direction. In the youngest forms there are no ribs or tubercules and the whorl is much wider. Some interstitial ribs arise on lower part of flank, but very few above a third of distance from umbilicus. With a radius of 70 mm. there are thirteen on a 10 mm. arc of periphery; at 55 mm. fifteen ribs; at 23 mm. twenty ribs; at 12 mm. twenty-eight ribs. The ribs bend slightly backward at top of umbilical edge; thence to the middle of flank there is a forward inclination, but from that point the ribs pass straight over periphery without any curve.

Suture-line is highly dissected. Median saddle much ornamented. External saddle deeply bifid, but external half much larger than internal half. First lateral saddle also deeply bifid, but internal portion much smaller than external portion. Second lateral saddle small. Six auxiliary saddles. External lobe wide with several frilled projections. First lateral lobe very deep and noticeably wanting in symmetry, for the projections and forks are much more developed on external than on internal side. Second lateral lobe much shallower, but still wanting in symmetry. Auxiliary lobes small and unimportant, but with the saddles form a deep umbilical lobe. Antisiphonal lobe also deep and again wanting in symmetry. The saddle next to it is very high, but the four others rapidly decrease in height, and the lobes are small, and thus the internal side of umbilical lobe is extremely steep. Both internal and external portions of suture-line have a remarkable resemblance to *Dalmasiceras*, and a rather less marked one to *Puzosia*.

A specimen of this species was sent to Professor Kilian, who kindly examined it, and returned it with a note: "*Kossmaticeras* (*Madrasites*) n. sp., possibly the mature form of *M. bhavani* var. *densicostatus*." I consider, however, that it is to be distinguished from that species by the fineness of the costation, the gradual slope into the umbilicus, the indistinct constrictions, the small size of the umbilical tubercles.

Two adult specimens and several smaller ones from Batley and Bull's Point, and a small one from Whangaroa. The type is in the Otago Museum.

Maorites densicostatus Kilian and Reboul. (Plate 24, fig. 1; Plate 44, fig. 2; Plate 45, fig. 4.)

Compare the species mentioned below under *Maorites suturalis* n. sp.

Dimensions of species of *Ammonites* apparently related to *Maorites densicostatus* :—

	A.		B.		C.		D.		E.		F.		G.	
Diameter ..	49	100	55	100	60	100	93	100	63	100	125	100	142	100
Height of whorl ..	23	47		40		50		42	30	47	51	40	60	42
Width of whorl ..	12	24		34		36		21	18	29	31	25	43	30
Umbilicus ..	12	24		33		16		29	13	21	31	25	35	24

	H.		J.		K.		L.		M.		N.	
Diameter		100	74	100	36	100	66	100	38	100	65	100
Height of whorl ..		40	35	47	15	42	26	40		37		41
Width of whorl ..		31	22	30	14·5	40	24	36		32		31
Umbilicus		33	18	24	11	30	22	33		24		26

A, *Maorites densicostatus* K. & R., Bull's Point, Kaipara Harbour, N.Z.; B, *Ammonites kandi* Stol. (11, pl. 70, fig. 4); C, *Ammonites aemilianus* Stol. (11, pl. 70, fig. 7); D, *Ammonites madrasinus* Stol. (11, pl. 70, fig. 1); E. *Kossmaticeras* (*Madrasites*) *bhavni* var. *densicostatum* Kilian and Reboul (46, pl. 15) (measured from a cast kindly presented by Professor Kilian); F. *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostatum* K. & R. (46, pl. 18, fig. 1); G. *Kossmaticeras tenuicostatum* Marshall (49, pl. 33, fig. 1); H, *Jacobites waitapuensis* n. sp., Whangaroa, N.Z.; J, *Maorites, suturalis* n. sp. Batley, Kaipara Harbour, N.Z.; K. L. *Kossmaticeras bhavani* Kossmat (28, p. 145); M, N, *Ammonites bhavani* Stol. (11, p. 138).

The table shows clearly how very similar the dimensions of this species are to those of Kilian and Reboul's form *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostatum*; but the suture-line of that species is said by the authors to be quite similar to the suture-line drawn by Kossmat of the form that he identified with *K. bhavani* Stol., and in that case it must be radically different from the suture-line of this species, which, as will be seen on Plate 24, fig. 1, is quite Puzosid in form. From inspection of the cast of his species that Professor Kilian was good enough to send me, however, it seems to me that the suture-line if developed would be similar to that of this species.

Ornamentation: There are numerous fine sharp ribs narrower than the intervening furrows, and narrower and sharper than in the closely allied species *Maorites suturalis*. Ribs at first bent forwards, but at about one-third of the flank they bend backwards and, becoming strictly radial, cross periphery without interruption and without any bend. Most of ribs start from tubercles at top of umbilical wall, but there are several interstitial ribs as well. A few deep constrictions, most noticable in last whorl. They have a moderate bolster-rib before and behind, and as they have a strong forward inclination they intersect several of the ribs, many of which fork close to posterior bolster. Constrictions cross periphery with a pronounced forward curve. Umbilical tubercles are numerous and are elongated radially.

Suture-line much less complex than that of *M. tenuicostata* and *M. suturalis*. Median saddle not so much divid d. External saddle deeply bifid, but, as usual, exterior portion is a good deal larger than interior. First lateral saddle unsymmetrically bifid. Second lateral quite small, and auxiliaries rapidly diminish in size and are steeply inclined. External lobe wide, but not nearly as deep as first lateral lobe, which has the usual want of symmetry, is wide and deep, and extends over almost half of length of suture-line. Second lateral lobe much smaller, and auxiliaries small and unimportant. The inclination of these elements causes suture-line to form a deep umbilical lobe. It is noticeable that, as is also the case in the other species of *Maorites*, the external saddle is exactly the same

width as the first lateral lobe; while in *Puzosia* it is about three-quarters of the width, and in *Desmoceras* the two are about equal. The external lobe in this genus is of greater importance than in other genera, and this makes the external saddle appear much more upright than in *Puzosia*.

One specimen only has been found, and it comes from Batley. The Indian species to which it is closely allied come from the Aryalur group, except *K. bharani* Stol. This comes from the Trichinopoly group, which is classed in the Lower Senonian, while the former are placed in the Upper Senonian. The New Zealand species has a rather broader and more rounded periphery than the Seymour Island specimen which it so closely resembles.

Maorites suturalis n. sp. (Plate 23, fig. 3; Plate 43, fig. 1; Plate 45, fig. 5.)

Compare—

1885. *Ammonites kandi* (11, p. 140, pl. 70, fig. 4).
1885. *Ammonites aemilianus* (11, p. 141, pl. 70, fig. 7).
1885. *Ammonites madrasinus* (11, p. 139, pl. 70, fig. 1).
1909. *Kossmaticeras (Madrasites) bharani* var. *densicostatum* (46, p. 30, pl. 18, fig. 1; pl. 15, fig. 4).

Dimensions:—

	A.		B.		C.		D.		E.	
Diameter	74	100	55	100	60	100	92	100	63	100
Height of last whorl ..	35	47		40		50		42	30	47
Width of last whorl ..	22	30		34		36		21	18	29
Umbilicus	18	24		33		16		29	13	21

A, *Maorites suturalis*, type, Batley, Kaipara Harbour, N.Z.; B, *Ammonites kandi* (11, p. 140, pl. 70, fig. 4); C, *Ammonites aemilianus* (11, pl. 70, fig. 7); D, *Ammonites madrasinus* (11, pl. 70, fig. 1): E, *Kossmaticeras (Madrasites) bharani* var. *densicostatum* (46, pl. 15, fig. 4).

It is evident that the dimensions of this species are very like those of Kilian and Reboul's species from Seymour Island.

Shell of moderate size, strongly involute (about two-fifths) and a good deal compressed. Umbilicus has a nearly vertical wall, and at the top of it the whorl has its greatest thickness. The sides are almost flat and the periphery is well rounded.

Ornamentation: Well-marked constrictions arise at intervals—about five in a revolution. They are inclined slightly forward and interfere somewhat with costation. They have a thick bolster before and behind. Ribs numerous, high, steep-sided, and narrowly rounded. Some of the ribs begin at umbilicus and nearly always bifurcate at top of the wall and interstitial ribs frequently begin at this point. Ribs at first incline forward, but at a distance of one-third of height of flank they bend back and become almost exactly radial. They pass straight over umbilicus without any diminution in size and without any bend. Constrictions have such a pronounced bend forward that they may interfere with as many as seven ribs; they are nearly straight, but bend slightly forward at about the middle, and pass over periphery with a strong forward curve. There are about fourteen umbilical tubercles in a half-whorl, and most of the ribs originate from them.

Suture-line is very much divided but is clearly of the type of *Dalmasiceras*, though the external lobe is of far greater importance. It can also be compared with the *Desmoceras difficile* and *beudanti* type, which Kilian and Reboul regard as derived from a Hoplitid ancestry (46, p. 17, footnote). First lateral lobe of great depth and importance, and markedly inequilateral hough bifid. There are two prominent secondary saddles, one on each

side of median line of lobe. The external of these as well as the other elements of the lobe on external side are much larger than those on internal side. Second lateral saddle small and much affected by development of umbilical tubercles. Auxiliary saddles small and progressively inclined, and thus suture-line forms a prominent and deep umbilical lobe. None of the specimens show internal portion of suture-line. Saddles all deeply bifid but not quite symmetrically. In external saddle exterior side is more strongly developed than interior side. In the first lateral saddle, however, the reverse is the case, interior portion being larger and more developed than exterior. Median saddle considerably frilled.

This species is clearly quite closely related to *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostatum*, which Kilian and Reboul have described from Seymour Island, but costation is a little coarser and umbilicus somewhat wider. The suture-line of that species has not yet been drawn, but reasons have been given on a previous page for thinking that it should not be placed in the genus *Kossmaticeras*, and that it is closely related to *Puzosia*.

The type specimen was sent to Professor Kilian, and after a brief examination of it he classed it as *Kossmaticeras* (*Madrasites*) *bhavani* var. *densicostatum*; but it appears to me that the costation and diameter of umbilicus are sufficient to distinguish it from the species *bhavani*. Further, the nature of the suture-line is entirely different from that of all the New Zealand species of *Madrasites*, and is certainly most distinct from that of *M. bhavani* given by Kossmat (28, pl. 8, figs. 5, 6), of which, however, Kilian and Reboul say, "La ligne suturale de notre espéce est bien conformé a celle du type" (46, p. 29).

This species is quite distinct from *K. haumuriensis* Hector as described and figured by Woods (57, p. 34, pl. 19, fig. 5*a*; pl. 20, fig. 1), for the suture-line of that species is of the *K. bhavani* (Stoliczka in Kossmat) type; the costation also is of a type different from that shown in the present species. No species that seems to be closely related to this one has yet been recorded from the other countries in which the Indo-Pacific fauna of *Ammonites* has been described, unless the species *Desmoceras hoffmani* from California be regarded as similar. It seems, however, that this species, in spite of its compressed form, is a true *Desmoceras*. Only one good specimen of *Maorites suturalis* has yet been found, though with it have been discovered a few fragments of other specimens at Bull's Point, the typical locality.

Puzosia Bayle.

Ammonites mayorianus was taken by Bayle as the genotype of this genus. Of it de Grossouvre (19, p. 171) says, "I keep the name *Puzosia* for the forms of a group of ammonites (*subplanulata*) which have a moderate umbilicus the whorls of which present transverse furrows and sickle-shaped ribs, which, however, are absent near the umbilicus and are marked only on the external region of the flanks. The suture-line offers a complete similarity to that of *Desmoceras* but is more reduced, and the first lateral lobe is longer than the ventral lobe. The lobes are trifid, and are somewhat more upright than in *Desmoceras*. The saddles, which are almost all similar, are divided into two parts by a deep lobule." He takes the suture-line of *D. subplanulatum* as typical. Sarasin (29A, p. 793) says that, as the genus had not been clearly defined, it had been little adopted by palaeontologists. He characterizes it as follows: "La coquille est

moyemment involutée avec les tours arrondis ou légèrement aplatés sur les côtés, toujours arrondis sur le pourtour externe, le pourtour de l'ombilic n'est jamais caréné et generalment arrondi, les tours sont marqués de nombre variable des constrictions droits ou flexueuses et regulièrement espacées entre les sillons. La coquille est tantôt lissée tantôt ornée de fines côtes, attenuée sur la partie interne des tours. Les cloisons sont toujours très découpées, le lobe ventral est le même longueur ou un peu plus court que le premier latéral; la selle ventral très reserrée à sa base s'élargit à la partie supérieure qui est profondement divisée par un lobe accessoire. Le premier lobe latéral est symétrique ou subsymétrique; la première selle latérale est généralment un peu plus elevée que la selle ventrale; sa partie interne est presque constamment plus haute que sa partie externe; le second lobe latéral, moins long et large que le premier, est toujours très disymmétrique; la deuxième selle latérale est moins haute que la précédente, elle est encore très découpée. Ensuite viennent trois à cinq lobes auxiliaires qui sont tantôt droits ou tantôt au contraire très obliques."

He classifies *Desmoceras* in four groups—(1) *D. difficile,* (2) *D. beudanti,* (3) *D. emmerici,* (4) *D. mayorianum* d'Orb. = *Amm. planulatus* Sow. The last two of these divisions are considered by him to constitute the subgenus *Puzosia.*

Zittel (11A, p. 465) divided the genus *Desmoceras* into five groups—(1) *D. beudanti,* (2) *D. difficile,* (3) *D. emmerici,* (4) *D. planulatum,* (5) *D. gardeni.* Kilian and Reboul refer the *beudanti* and *difficile* groups to the family of Hoplitidae, the *mayoriana* and *angladei* groups to the Phylloceratidae.

Kossmat in 1897 (28, p. 106) distinguishes between three groups of Desmoceratids: (1) *Desmoceras emmerici* Rasp. with a very regular suture-line. The separate lobes and saddles decrease little by little and extend to the umbilicus. (2) *D. planulatum* Sowerby (*Puzosia* Bayle). A distinctly-developed depressed umbilical lobe. The external lobe is almost always a good deal shorter than the first lateral lobe, and this makes it appear as though the external saddle were inclined outwards. The various lobe elements are not arranged with any regularity. He states that this group is closely related to *Ammonites beudanti* d'Orb. on the one hand, and with *Holcodiscus* through *H. pondicherryianus* on the other, as well as with *Pachydiscus.* (3) *D. gardeni* (*Hauericeras* de Grossouvre) includes keeled forms from the Upper Chalk, which in their other characters come very close to the group *Ammonites planulatus.*

Kilian and Reboul make the following comment (46, p. 17): "On réunit souvent à tort nous semble-t-il, en une même groupe, les *Desmoceras* s. str. (groupe *beudanti-difficile*) et les *Puzosia* (*P. angladei, P. mayoriana,* etc.) ces deux rameaux ne semblent cependant avoir entre eux aucun rapport genetique; le premier dérive sans doute des *Holplitides* (sensu lato) specialement de Leopoldia, et le second peutêtre des *Phylloceratides* par l'intermediare de *Sowerbyceras* (*Tortisulcati*) et de *Silesites ?* "

Zittel in 1895 and Hyatt in 1913 included *Puzosia* and *Hauericeras* in the Desmoceratidae. This relationship was the one adopted also by Yabe in 1903 (37, p. 30).

Pervinquière ("Sur quelques Ammonites du Crétacé Algerien," *Mem. Soc. Geol. Fr.*, vol. 17, 1910, p. 31) appears to use *Puzosia* in the sense defined by Sarasin.

Jacob (44, p. 26) divides *Desmoceras* into four groups, the last of which is *Puzosia*, with the genotype *P. mayoriana*, which has a symmetrical lobe. This author (p. 55) places several of Sarasin's second group of *Desmoceras* in *Sonneratia*, which is referred to the Hoplitidae.

Spath in 1922 makes the following remark (54, p. 120): "The genera *Pachydiscus*, *Parapachydiscus*, *Parapuzosia*, *Kossmaticeras*, and the many allied developments can all be derived from Desmoceratid stocks which persisted during the Upper Cretaceous."

In spite of the weight of these authoritative opinions, and with comparatively a small amount of material to study, the author, relying on the character of the suture-line (both external and internal), as well as on the form of the shell, is inclined to regard *Puzosia*, *Hauericeras*, and *Maorites* n. gen. as derived from the Hoplitidae sensu lato.

Puzosia angusta n. sp. (Plate 22, fig. 5; Plate 41, fig. 1.)

Compare—

1865. *Ammonites durga* Forbes, in Stol. (11, p. 143, pl. 71, figs. 6, 7).

1898. *Puzosia compressa* Koss. (28, p. 119, Taf. 18, fig. 4 = *Ammonites durga* Forbes, in Stol.).

Dimensions:—

	A.		B.	
Diameter	143	100	190	100
Height of last whorl	52	36	64	34
Width of last whorl	18	12·5	34	18
Umbilicus	53	37	74	39

A, *Puzosia angusta* n. sp., Bull's Point, Kaipara Harbour, N.Z.; B, *Puzosia compressa* Koss. (28, p. 119).

The dimensions given above emphasize the feature of the high and narrow whorl, which seems to be more extreme than in any other species of this genus of which descriptions are available. Involution nearly one-half, and whorls rapidly increasing in height. Flanks nearly flat and periphery sharply rounded, with the broadest point about two-thirds of distance from umbilicus to periphery. Umbilical wall short but vertical, passing into flank over a sharp angle of a little more than 90°.

Ornamentation: Lower two-thirds of whorl without costation, but upper third with numerous low rounded ribs arising without any tubercles or projections on the shell. First they are directed slightly forward, but they soon bend to a much more acute angle, and, though they diminish in size towards periphery, they distinctly pass over it with a sharp forward loop. Prominent constrictions, apparently five in a revolution, take their rise from umbilicus, and each of them has a high bolster behind. At first the constrictions slope forward at a moderate angle, and near top of flank they bend farther forward and become parallel with ribs and pass over periphery with a sharp curve forward.

Suture-line of the typical Puzosid form, not dissimilar from that of *P. compressa*, but more finely divided. In the only specimen that shows a suture-line the external saddle, unfortunately, cannot be seen. First lateral lobe deep and, as usual, wanting in symmetry. First lateral saddle almost equally bifid, and auxiliary lobes and saddles, few in number, form a deep umbilical lobe.

This species is certainly closely related to *Puzosia compressa* Koss., which comes from the Utatur formation of India, regarded as of Cenomanian

age. It appears to be confined to this formation, for the small specimen figured by Stoliczka is classified by Kossmat as *Hauericeras rembda.*

Three fragmentary specimens only have been found, and all come from the north side of Bull's Point.

PARAPUZOSIA Novak, 1913.

Novak states that the inner whorls have the typical *Puzosia* form with constrictions. These disappear in the outer whorls and ribbing is developed (45, p. 350).

Novak established this genus for the *Puzosia denisoni* group; but, as Spath points out, Novak described and figured *P. daubréei* only, and consequently Spath takes *P. daubréei* as the genotype of *Parapuzosia.* This genus, he says, has the course of the radial line and the strongly projected constrictions of the *P. subplanulata* type, different from the straight ornamentation of the Campanian (54, p. 127). He includes in this genus the Indian species *P. gaudama* Forbes and *P. indopacifica* Koss. In both these species the ribs cross the periphery and there are no tubercles.

At the same time Spath established the genus *Kitchinites*, including therein *K. pondicherryanus* Koss., *K. japonicus* Spath = *Desmoceras gaudama* (Forbes) Yokoyama, as well as *K. darwini* Phil., all rather coarse-ribbed types, with the ribs crossing the periphery, though they are absent on the lower part of the flanks. There are no tubercles. The first of these three species has a typical *Madrasites* suture-line. *K. darwini*, however, has a suture-line of Puzosid type, and the strong projections of the constrictions of that type.

The New Zealand species *Parapuzosia brevicostata* appears to be closely related to *P. gaudama* on the one hand and to *Kitchinites darwini* on the other; but I am inclined to retain it in the genus *Parapuzosia*, as explained later.

Parapuzosia brevicostata n. sp. (Plate 24, fig. 3; Plate 43, fig. 2.)

Compare—

1845. *Ammonites gaudama* Forbes (1, p. 113, pl. 10, fig. 3).
1865. *Ammonites planulatus* Sowerby, in Stol. (11, p. 134, pl. 67, fig. 1).
1890. *Desmoceras gaudama* Forbes, in Yokoyama (17, p. 184, Taf. 18, fig. 14; Taf. 19, figs. 5 *a*, *b*) = *Puzosia indopacifica* Koss. (28, p. 117) = *Kitchinites japonicus* Spath (54, p. 127).
1909. *Puzosia* sp. Kilian and Reboul (46, p. 19).
1895. *Puzosia darwini* Steinmann (26, p. 73, Taf. 5, figs. 3 *a*, *b*, *c*, fig. 4) = *Kitchinites darwini* in Spath (54, p. 127).
1922. *Parapuzosia gaudama* Forbes, in Spath (54, p. 126).

Dimensions:—

	A.		B.		C.		D.	
Diameter ..	56	100	89	100	56	100	190	100
Height of last whorl	26	46	37	42	23	41	64	34
Width of last whorl	13	26	27	30	19	34	34	18
Umbilicus ..	19	34	25	28	18	32	74	39

A, *Parapuzosia brevicostata*, specimen from Nedler's, Whangaroa, N.Z.; B, *Parapuzosia gaudama* (28, p. 115); C, *Puzosia planulata* (28, p. 112); D, *Puzosia compressa* (28, p. 119).

Periphery gently rounded, the curve passing rapidly into a long flat flank. A short curve at the edge of umbilicus passes quickly into a vertical umbilical wall.

Ornamentation: A number of low rounded ribs commence at umbilicus and are at first directed radially, but towards outer side of flank they curve

forward and become thinner, and are almost lost at periphery. At the point where the forward bend commences a secondary rib arises between each pair of primary ribs. Deep constrictions arise at intervals, but only two in a half-whorl. They are at first radial, but soon bend forward more strongly than ribs, and are continuous across periphery, which they cross in a strong almost V-shaped curve.

Suture-line has a moderately deep external lobe, which is deeper than is usual in *Puzosia*, though little more so than in *Parapuzosia gaudama* (28, pl. 16, fig. 4) and *Puzosia crebrisulcata* (28, pl. 18, fig. 2). First lateral lobe, as usual, is of great importance, but in this species is rather more symmetrical than usual. External saddle rather wide, bifid, with a rather wide median lobe. Second lateral lobe very small, and three auxiliaries much inclined, forming a deep umbilical lobe.

This species differs from *P. gaudama* in its narrower form, distinction between primary and secondary ribs, and in the failure of the ribs to maintain their strength across periphery. The same characters distinguish it from *P. crebrisulcata*, and in addition the small number of constrictions it shows. *Kitchinites darwini* from Quiriquina has rather stouter ribs which cross periphery, a broader form, more numerous constrictions, and a suture-line more finely divided. The variety *P. gaudama* var. *intermedia* does show primary and secondary ribs, and, while it is not so narrow as *P. compressa*, it has a smaller umbilicus. *P. compressa*, also, has little sculpture (28, p. 119).

Suture-line shows a general similarity to that of *P. gaudama*, but its lobe elements are more nearly symmetrical, the external lobe is more transgressive, and median saddle is more frilled. *P. stoliczkai* Koss. has a median saddle that is nearly simple, and its ribbing consists of wide low rounded ribs.

A single specimen only, in indifferent state of preservation, has been found at Whangaroa.

Parapuzosia ordinaria n. sp. (Plate 24, fig. 4; Plate 31, figs. 6, 7.)

Compare—

1885. *Ammonites bhima* Stol. (11, p. 137, pl. 69, figs. 1–3).

Dimensions :—

	A.		B.		C.	
Diameter ..	28	100	48	100	130	100
Height of last whorl	12·5	45		41		46
Width of last whorl	9	32		33		34
Umbilicus	8	28		30		23

A, *Parapuzosia ordinaria* Batley, Kaipara Harbour, N.Z.; B, *Ammonites bhima* Stol. (11 p. 137); C, *Ammonites bhima* Stol. (11, p. 137).

Shell small; involution nearly one-half; whorls much higher than wide and rapidly increasing. Umbilical wall at first steep, then gently sloping, with the thickest part of whorl rather more than half the distance from umbilicus to sharply-rounded periphery. Umbilicus shallow.

Ornamentation: Surface of shell practically destitute of ornament except for very fine striations or growth-lines, which at first bend backward but on the flank curve forward and pass over periphery with a sharp forward curve. This, however, does not prevent the shell from having a bright and polished appearance, and a strong lens is required to make the striations distinct. Seven constrictions in the last whorl, bordered behind by a rounded bolster rib. They are directed forward at first, and on upper

part of flank they bend still more forward, finally passing over periphery in a sharp forward curve.

Unfortunately the suture-line is not well preserved. External lobe shallow and narrow. First lateral lobe a good deal deeper and very wide, and nearly symmetrical. Saddles bifid but not deeply dissected. Second lateral saddle already on umbilical slope. Three auxiliary saddles all strongly inclined and forming a deep umbilical lobe.

The sloping nature of umbilical wall, the smooth surface, as well as the relatively simple suture-line, distinguish this from all other species of *Parapuzosia* of which descriptions can be found in the available literature. It seems to be closer to *Puzosia bhima* Stol. (11, p. 137, pl. 69, figs. 1–3) than to other species. However, this species comes from the Cenomanian, and is apparently related to *Ammonites octosulcatus* in the Grey Chalk in the Isle of Wight. It is probable that the resemblance is more apparent than real.

A single specimen has been found at Batley.

TAINUIA n. gen.

Genotype: *Tainuia aucklandica* n. sp.

Shell with flat flanks, especially in the inner whorls. Costation strong and coarse, with ribs strongly inclined forwards. Five constrictions in a whorl running parallel to ribs. Umbilical and siphuncular tubercles on each rib. On each rib a number of rounded tubercles. Suture-line much dissected. Median saddle rather frilled. First lateral lobe bipartite but not quite symmetrical, much deeper than external lobe. Saddles bifid and suture-line sloping backward rapidly from edge of umbilicus.

At first sight the ornamentation of this form suggests that it belongs to the genus *Acanthoceras*: but the constrictions distinguish it from that genus, and the distinction is emphasized by the suture-line with its deep unforked first lateral lobe. On the other hand, Kossmat has a seventh group of species of *Acanthoceras* (28, p. 25), "VII Arten aus der Verwandschaft des *Acanthoceras vicinale*," which has the main characters of form and ornamentation (except the constrictions) and the deep slightly unsymmetrical bipartite first lateral lobe. This new genus *Tainuia* is evidently close to this group, the members of which are far from typical species of *Acanthoceras*. This is also true of the compressed variety of *Acanthoceras rotomagense* Stol. (11, pl. 34, figs. 5 *a–c*), which, however, is placed by Kossmat under *A. gothicum*, a much less compressed form with a very different suture-line (28, p. 198, Taf. 25, figs. 3 *a*, *b*).

In external form *A. pseudodeverianum* Jimbo (22, p. 32, Taf. 5, figs. 1 *a*, *b*) closely resembles the genotype, but here again the suture-line is very distinct.

The genus resembles *Parapuzosia*, in respect of its compressed form, inclination of the constrictions, and in the nature of the suture-line itself. On the other hand, it is wholly different from *Parapuzosia* in the character of its ornamentation. In the absence of specimens of the Indian species referred to above it is not possible to offer any suggestions as to whether any of them should be included in this genus. The suture-lines as drawn by Stoliczka and Kossmat do not show sufficient detail to make any close comparison, but it is probable that they are far less dissected than that of *Tainuia*. In the three forms *Acanthoceras discoidale* Koss., *Acanthoceras vicinale* Stol., and the compressed variety of *Acanthoceras rotomagense*

de France in Stol. (non *A. gothicum* Koss., 28, p. 198, which has a very different suture-line), there is often an absence of the median line of tubercles. This, however, must not be regarded as too important a difference. Kossmat, for instance, says, "das Fehlen der siphonalen Knotenreihe bilden ebenfalls keinen durchgreifenden Unterscheid."

A fragment of a specimen of the only species was sent to Professor Kilian, who notes, "une forme adulte [of *Gunnarites antarcticus*] prenant outre les crénelures des côtes, des tubercles siphonaux produisant une convergence vers le type *Acanthoceras*" (55, p. 175). I find myself unable to adopt this view.

This genus is certainly similar in some respects so far, at any rate, as ornamentation is concerned—to *Mortoniceras* (Meek), a genus which is diagnosed by de Grossouvre as follows: "Ce sont en général des coquilles dont le section des tours est plus élevé que large de forme subquadrangulaire, à bord externe large et ornée sur la ligne siphonale d'une petite quille arrondie très peu saillante. La cloison rassemble par certains traits à celle des *Acanthoceras* sauf que le premier lobe latéral est arrondi à son extrémité et termine par des digitations avant tout à peu près la même valeur de sorte que l'on n'y distingue pas, ou tout ou moins très peu nettement la fourche terminale caractéristique des *Acanthoceras* et des *Stoliczkaia.*"

Whilst in general form not far distant from *Mortoniceras*, there is no keel, but a well-defined row of ventral tubercles. However, von Heupen (52, pp. 42, 43) states that in *Peroniceras* and *Acanthoceras* a keel may be replaced by a row of tubercles. Thus this distinction falls to the ground. In this genus there are five constrictions in a whorl. The suture-line, however, is much more divided than that of *Mortoniceras* as figured by Spath and von Heupen. The median saddle, in particular, is frilled. The first lateral lobe is bifid, not forked. There are three auxiliary saddles, and the suture-line falls backward considerably from the umbilicus. On the other hand, the suture-line is very similar to that drawn by Crick of *Mortoniceras soutoni* (Baily) (53, pl. 20, fig. 4). Spath says of this, "The suture-line of an example of *M. soutoni* Baily, very close to Baily's type, with small umbilicus and comparatively smooth outer whorl, is given for comparison, since it differs from that figured by Woods and from the original drawing by Baily."

"Tainui" is the name of one of the canoes in which the ancestors of the Maori navigated the Pacific Ocean to New Zealand.

Tainuia aucklandica n. sp. (Plate 24, fig. 2; Plate 34, fig. 3; Plate 46, figs. 1–3.)

Dimensions:—

	A.		B.		C.		D.	
Diameter ..	195	100	125	100	121	100	210	100
Height of last whorl	71	36	43	34	42	35	90	43
Width of last whorl	56	29	34	27	35	29	72	34
Umbilicus ..	74	38	42	34	42	35	78	37

	E.		F.		G.		H.	
Diameter ..	65	100	134	100	139	100	76	100
Height of last whorl		46	66	49	60	43	32	42
Width of last whorl		41	38	28	38	27	31	41
Umbilicus ..		26	24	18	38	27	26	34

A, B, *Tainuia aucklandica* from Bull's Point, Kaipara, N.Z.; C, *Tainuia aucklandica* from Whangaroa, N.Z.; D, *Acanthoceras pseudo-deverianum* Jimbo (22, p. 32); E, *Ammonites compressus* Stol. (11, p. 66, pl. 34, fig. 5); F, *Ammonites vicinale* Stol. (11, p. 84, pl. 44; 28, p. 200, Taf. 25, fig. 2); G, *Acanthroceras discoidale* Koss. (28, p. 201, Taf. 25, fig. 1); H, *Acanthroceras gothicum* Koss. (28, p. 198, Taf. 25, fig. 3).

It will at once be seen from the table given above that *Tainuia aucklandica* in its dimensions comes quite close to *Acanthoceras pseudo-deverianum* Jimbo, and among the Indian species it comes closest to *Acanthoceras discoidale* Koss.

Shell large, discoid, with whorls much higher than wide. Involution about five-eighths. Umbilical wall steep, but sides soon rounded off into flanks, which are almost flat and slope gradually into a curve passing rather sharply over periphery. The thickest part is about one-third of the height from umbilicus.

Ornamentation: The shell is strongly ribbed—about twenty-one in each half-revolution. Most of ribs commence as moderate rather lamellar tubercles at top of umbilical wall, and pass over flanks almost radially or with a slight forward inclination, and over periphery with a distinct forward curve. There are four knots on each rib between umbilical tubercle and siphuncle, which increase gradually and uniformly in size towards siphuncle. The first is situated at about one-third of height from umbilical tubercle; the others divide the remaining space about equally, but are not quite regular in position. On median line there is an additional row of tubercles. Between each pair of ribs which arise from tubercles there is always one interstitial rib, which commences just below first tubercle of flank and has tubercles similar to those on ordinary ribs. Six constrictions in a revolution, and each of these has a strong bolster before and behind, relatively slightly tuberculated. The posterior of these intersects one interstitial rib. Some indistinct striations between ribs on body-chamber, which is rather more than half a whorl in size.

Suture-line much dissected. Median saddle somewhat frilled, and a great deal shorter than external saddle, which is conspicuously bifid. First lateral lobe very deep and conspicuously bifid, though the two sides are not symmetrical. Second lateral lobe not nearly so deep, and auxiliary lobes small and a good deal inclined. The other saddles as far as second auxiliary are also bifid. Four auxiliary saddles only are present. Taking a broad view, it may be said that the suture-line is much more complicated than that of *Acanthoceras*; the first lateral lobe is much deeper and of more importance than in *Madrasites*, but has these qualities in a less degree than *Maorites*. The external lobe is not so deep as in *Parapachydiscus*, and there is a more decided slope towards the umbilicus. The first lateral lobe is distinctly wanting in the forked form that is so characteristic of *Acanthoceras* and *Mortoniceras*, to which genera the external form of *Tainuia* shows a good deal of resemblance, though the umbilicus is noticeably smaller and the periphery is far more rounded.

Three specimens of this form have been found: the type comes from Whangaroa; the other two from Bull's Point, Kaipara Harbour. The type is in the Auckland Museum.

PARAPACHYDISCUS Hyatt *emend* Spath (54, p. 122).

Genotype: *P. gollevillensis* D'Orb.

I have been unable to find a diagnosis of the characteristics of this genus, and give the following short abstract of de Grossouvre's description of the genotype (19, p. 214, pl. 29, fig. 10; pl. 31, fig. 9):—

Shell discoid compressed, involution more than one-half. Umbilicus of moderate size with vertical walls. Whorls much higher than wide, and

in the young forms quite smooth. Umbilical ribs few (nine in a whorl). Ribs of peripheral region short, and become less prominent in the more mature individuals. Suture-line much the same as in *Pachydiscus*. Median saddle rather frilled. External lobe not quite so deep as first lateral lobe, which is symmetrical. Saddles nearly symmetrically divided by a deep secondary lobe. Frilling of suture-line extremely complex and intricate.

Spath in a critical survey of this genus establishes a large number of subgenera, but it seems that this species should be included in his *Parapachydiscus* sensu stricto (54, p. 122).

All the species of this genus are found in the Campanian or the Maestrictian.

Parapachydiscus rogeri n. sp. (Plate 25, fig. 2; Plate 47, figs. 1, 2.)

Compare—

1921. *Parapachydiscus* aff. *wittekindi* Sch., in Spath (53, p. 229, pl. 24, fig. 1).
1885. *Parapachydiscus tweenianus* Stol. (11, pl. 54, fig. 3).
1895. *Parapachydiscus tweenianus* Stol., in Koss. (28, p. 102).

The specimens of this large species are unfortunately so imperfect that approximate measurements only can be given. The most complete specimen represents perhaps only one-eighth part of a complete individual, but it measures 350 mm. by 300 mm. by 120 mm. and weighs about 40 kilograms. This fragment is entirely septate, and it is probable that the complete individual with the body-chamber would be as much as 774 mm. in diameter. Involution considerable, but the proportion cannot be stated. Flanks gently rounded, the curve gradually increasing as the periphery is approached. Lower part of umbilical wall is almost vertical, but afterwards slopes off gradually to periphery. The surface has large low rounded ribs. In the portion nearest to periphery that is shown in the specimens the distance from the crest of one rib to that of the next is 46 mm. The ribs arise at base of umbilical wall and are at first directed backwards at a sharp angle, but they soon bend, and at about one-third of flank they become radial and maintain this direction as far as can be seen. Here and there a faint striation can be seen parallel to the ribs. The shell matter close to umbilicus is as much as 5 mm. in thickness.

Suture-line: Unfortunately the greater part of the specimen is considerably eroded, and it is not possible to see the details of the external lobe or of the external saddle. First lateral lobe deeper than external lobe and nearly symmetrical. Second lateral lobe also deep, but first auxiliary lobe is far shallower; beyond that the suture-line cannot be seen. Secondary lobe in saddles extends rather less than half-way to base, and the two divisions into which it splits the saddle are not quite equal. In external saddle exterior half is larger than interior, but in first lateral saddle the reverse is the case. Both saddles and lobes are complexly divided.

Ornamentation resembles that of the species from Zululand compared by Spath with *P. wittekindi* Schluter (53, p. 229, pl. 24, fig. 1). In *Parapachydiscus rogeri*, however, the ribs are carried right down into umbilicus with a strong forward sweep, whereas in the Zululand species they disappear on the edge of umbilical slope. Suture-line of this species is not very different from that of *P. quiriquinae* Phil. (26, p. 74, pl. 6, fig. 3 *a*, *b*, text-fig. 5), though it cannot be seen whether the inner whorl is

tuberculate as in that species, which also has more numerous ribs, that do not decrease much towards periphery. It resembles *P. tweenianus* Stol. (11, p. 107, pl. 54) more closely than any of the other of the Indian species. *P. tweenianus* is said by Kossmat to be similar to a species, apparently unnamed, from Vancouver (28, p. 122).

Only two fragments of this species have been found, both at Bull's Point, one at each end of the exposure of Cretaceous rocks at that place.

Named in honour of the finder, Roger T. Marshall.

NOWAKITES Spath (54, p. 124).

Genotype: *N. carezi* de Grossouvre.

The following diagnosis is drawn from de Grossouvre's description of the genotype (19, p. 190):—

Shell discoid compressed. Spire formed of involute whorls which increase rather slowly in height and width. Flanks slightly convex, and external border rounded with a small umbilicus. Ribs very slightly oblique, leaving the umbilical tubercles in pairs. Between the pairs there are usually one or two auxiliary ribs. Occasionally a transverse constriction, wide but not deep. Mature individuals show shorter and shorter auxiliary ribs. Suture-line not known. Occurs in the Coniacian of Corbières.

The genus *Nowakites* is a division of the genus *Parapachydiscus* of Hyatt.

Nowakites denticulatus n. sp. (Plate 25, fig. 3; Plate 38, figs. 5, 6.)

Shell in too imperfect a condition to allow of measurements. Shell of moderate size, with aperture a good deal higher than wide. Numerous ribs with high sharp crests and wide rounded intervals. The sharp crests are finely denticulated, but it is only where the state of preservation of the shell is particularly good that this feature can be seen. Ribs arise in pairs from tubercles on edge of umbilicus, but between every pair are one or two interstitial ribs. All of these pass straight over periphery without any noticeable curvature, except where the specimen has been slightly distorted by pressure. Periodic constrictions indistinct.

Only a small portion of suture-line can be seen. It is distinctly of the Parapachydiscoid type, complex and much divided, and with a deep straight first lateral lobe.

The sharp costation and fine denticulations are the dominant features of this species, which in general respects somewhat resembles *Kossmaticeras antarcticum* var. *bhavaniformis* Kilian and Reboul from Seymour Island (46, p. 33, pl. 15, fig. 2). I am tempted to compare it with *Kossmaticeras* (*Grossouvrites*) *gemmatum* Hupe from Quiriquina, a specimen of which has been recorded by Trechmann (56, p. 387) from the Selwyn Rapids, in the South Island.

In virtue of its ornamentation, form, and suture-line, *K. gemmatum* ought, I think, to be placed in the genus *Parapachydiscus*. Kilian and Reboul remark that it approaches very close to *Pachydiscus* in the character of the suture-line (46, p. 23, also p. 42). So far as European species are concerned, I am inclined to say that *P. sayni* de Gross. (19, p. 181, pl. 39, fig. 2) comes nearest to the present species.

One specimen only has been collected. It comes from the northern side of Bull's Point, Kaipara Harbour, close to the spot where *Parapachydiscus rogeri*, *Ancanthoceras ultimum*, and *Gaudryceras subsacya* were obtained.

Hauericeras de Grossouvre, 1893.

The genus is described by its author as follows: Shells with a large umbilicus. Whorls thin and high, with a keel on the margin. Flanks slightly convex or even flat, without sculpture but showing constrictions more or less clearly. The suture-line is quite analogous to that of *Desmoceras*, *Puzosia*, and *Pachydiscus*. The first lateral lobe is as long as the external lobe (19, p. 219).

Kossmat says that *Hauericeras* is separated from *Puzosia* by the sharp external keel, but remarks later that in a young example of *Hauericeras rembda* the keel is not developed, and that the same is true of young examples of *H. gardeni*. There is the same development of auxiliary lobes as in *Puzosia*, which has the external lobe always distinctly shorter than the first lateral lobe, and the first lateral lobe and external saddle are inclined. In *Hauericeras* the first lateral lobe is the same length or only slightly longer than the external lobe. The external saddle is straight and not regularly bifid (28, p. 122).

Van Hoepen says that in the South African examples the first lateral lobe is distinctly longer than the external lobe. In *Puzosia planulata* the external saddle reaches farther forward than the first lateral, but in *Hauericeras* the reverse is the case. He points out that in the smaller whorls the umbilical surface is perpendicular to the plane of symmetry, while in the older whorls it is inclined (52, p. 27).

Yokoyama says that in the Japanese example the lobes are quite irregularly trifid and not so deep as in the Indian example. This asymmetry is noticeable in the South African example (52, text-fig. 5) and in the Indian specimens (11, pl. 33, fig. 4), but not in the Nanaimo example figured by Kossmat (28, Taf. 18, fig. 10).

Hauericeras ngapuhi n. sp. (Plate 24, fig. 5; Plate 43, fig. 3: Plate 45, fig. 3.)

Compare :—

1855. ***Ammonites gardeni*** Baily, *Quart. Journ. Geol. Soc.*, vol. 11, p. 456, pl. 9, fig. 3.
1864. ***Ammonites gardeni*** Baily, in Stoliczka (11, p. 61, pl. 33, fig. 4).
1879. ***Ammonites gardeni*** Baily, in Whiteaves (7, p. 102).
1890. ***Desmoceras gardeni*** Baily, in Yokoyama (17, p. 184, pl. 20, fig. 10).
1906. ***Hauericeras gardeni*** Baily, in Woods (40, p. 332).
1909. ***Desmoceras (Hauericeras) gardeni*** Baily, in Kilian and Reboul (46, p. 18).
1921. ***Hauericeras gardeni*** Baily, in Spath (53, p. 238, text-fig. 12).
1921. ***Hauericeras gardeni*** Baily, in Spath (59, p. 50, table).
1921. ***Hauericeras gardeni*** Baily, in van Hoepen (52, p. 27, text-fig. 15).
1922. ***Hauericeras gardeni*** Baily, in Spath (54, p. 129).

The dimensions given below show that the species is closely related to the widely-occurring species *Hauericeras gardeni* Baily, which has been recorded from so many countries that lie on the border of the Pacific Ocean. At the same time, the differences are certainly great enough to be

of specific value. In all the three specimens found there is no keel, but this may be due to their immaturity.

Dimensions :—

			B.		C.		D.		E.		F.	G.	
Diameter ..	22·2	100	23·5	100	27	100	120	100	26	100	100	79	100
Height of last whorl	9	40	10	42	12	44			10	38	35	32	40
Width of last whorl	6·8	30	7	30	8	30			5·75	22	19	..	
Umbilicus ..		31	7	30	8	30		42	10	38	39	27	37

A, B, C. three specimens of *Hauericeras ngapuhi* from Whangaroa, N.Z.; D, *Ammonites durga* Forbes — *Puzosia compressa* Koss. (11, p. 143); E, *Hauericeras gardeni* Spath (54, p. 130); F, means of measurements of thirty specimens of *Hauericeras gardeni* by Crick, Spath (54, p. 129); G, *Hauericeras welschi* de Grossouvre (19, pl. 35, fig. 9).

Shell small, discoid and much compressed. Whorls high and narrow. Umbilical wall nearly vertical, with a sharp angle to the almost flat flank. Periphery evenly rounded, and involution rather more than a third. Umbilicus of moderate size.

Ornamentation: The surface of shell quite smooth except for conspicuous constrictions, which number six in last whorl. They commence at bottom of umbilicus and, directed strongly forward, pass in a straight line to periphery, over which they pass in a sharp forward curve.

Suture-line not very highly divided. First lateral saddle a good deal higher than the others, and auxiliary saddles fall away posteriorly to a distinct umbilical lobe. There are in all eight saddles. First lateral lobe deeper than external lobe and symmetrical. Second lateral lobe straight but much shorter, and auxiliary lobes much inclined. Saddles are rather more regularly bifid than is usual in this genus.

The shape and ornamentation of the three specimens have caused me to place the species in this genus. Unfortunately the shell matter is not preserved on the periphery, and consequently no keel is to be seen—probably it was not developed; though, as pointed out, the small size of the specimens and their probable immaturity may account for this. The table of dimensions shows that *Hauericeras ngapuhi* has a higher whorl than the related species, but at the same time it is wider and has a smaller umbilicus. As shown in the table on pages 196–97, *Hauericeras gardeni* has a very wide occurrence in the countries that border the North Pacific.

Three specimens, one from Bull's Point and two from Whangaroa.

The Ngapuhi is a famous Maori tribe of New Zealand.

SCHLUTERIA de Grossouvre.

This genus was established by de Grossouvre to include some species of the Upper Chalk closely allied to *Phylloceras* by their form and ornamentation, but their suture-line clearly approaches that of *Puzosia* and *Pachydiscus*, and differs entirely from that of *Phylloceras* in the absence of the large foliaceous terminations (19, p. 216). De Grossouvre, however, as Spath has pointed out (53, p. 46), included in this genus certain species of *Phylloceras* related to *P. nera*. Spath has therefore emended the genus, and has taken as the genotype *Schluteria larteti* Seunes.

Schluteria rarawa n. sp. (Plate 19, fig. 10; Plate 32, figs. 7, 8.)

Compare :—

1845. *Ammonites diphylloides* Forbes, *Trans. Geol. Soc.*, ser. 2, vol. 7, p. 105, pl. 8, fig. 8.
1865. *A. diphylloides* Stol. (11, p. 119, pl. 59, figs. 8, 9).
1897. *Desmoceras diphylloides* Koss. (28, p. 109, Taf. 19, figs. 8 *a*, *b*, *c*, 9 *a*, *b*, *c*)

Dimensions :—

	A.		B.		C.	
Diameter	11	100	22	100	34·6	100
Height of last whorl ..	6	55	11	50	21·1	58
Width of last whorl ..	6	55	11	50	16·3	47
Umbilicus		..	4	18	2·8	08

A, *Schluteria rarawa*, Kaipara Harbour, N.Z.: B, *Schluteria* (*Desmoceras*) *inanis* Koss. (28, p. 107); C, *Schluteria* (*Desmoceras*) *crassa* van Hoepen (52, p. 21).

Shell small, completely involute, with whorls rapidly increasing. Wall of umbilicus sloping steeply at first but soon rounding off into the flanks, which maintain the same curve. The whole aperture, therefore, is nearly circular.

Ornamentation: Very fine ribs can be distinguished on umbilical slope, the specimens being extremely well preserved. About every fifth is stronger than the others. They curve sharply backward first, then forward, but they disappear about half-way up the flanks. A strong lens is required to make them visible, as to the naked eye the surface appears smooth and polished. Six constrictions in a whorl, which are shallow and bordered behind by a low but wide bolster rib.

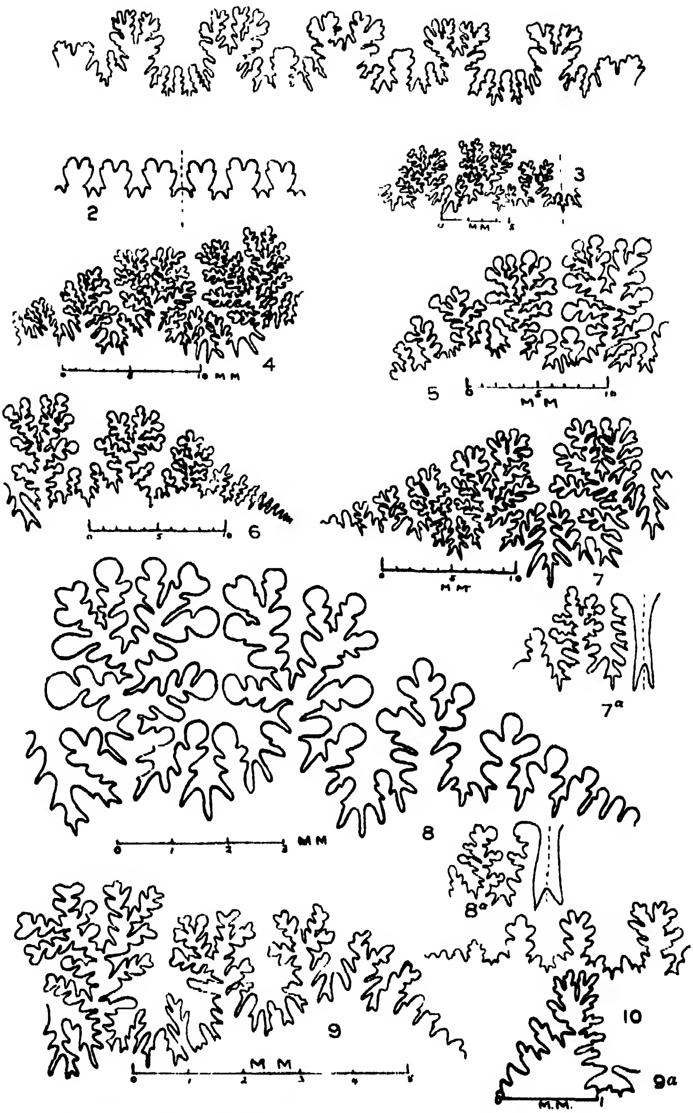
Suture-line with nine saddles decreasing gradually and uniformly from periphery to umbilicus. Exterior and first lateral saddle bifid. Lobes symmetrically bifid and much wider than saddles. Lobes uniformly of same depth, and the whole suture-line is linearly radial in direction.

Schluteria simplex from Pondoland has a narrower whorl than this species, but *Schluteria crassa* from the same country comes nearer to it in form. The species certainly comes close to *Desmoceras loryi* from Seymour Island, described by Kilian and Reboul (46, p. 18, pl. 1, figs. 4, 5), though all the specimens that have been found in New Zealand are much smaller. This species is much more inflated than *S. diphylloides* Forbes and than *S. inane* Forbes. The suture-line is spaced out like that of *S. phyllimorphum* Koss., but the form and size are quite different. The suture-line is not unlike that of *S. diphylloides* and *S. inanis*.

A specimen in the collection of the Geological Survey of New Zealand, which was found by McKay near Awanui, on the east coast of the North Island, comes very close to this species, but it is badly preserved. Several specimens have been obtained from Batley and Bull's Point.

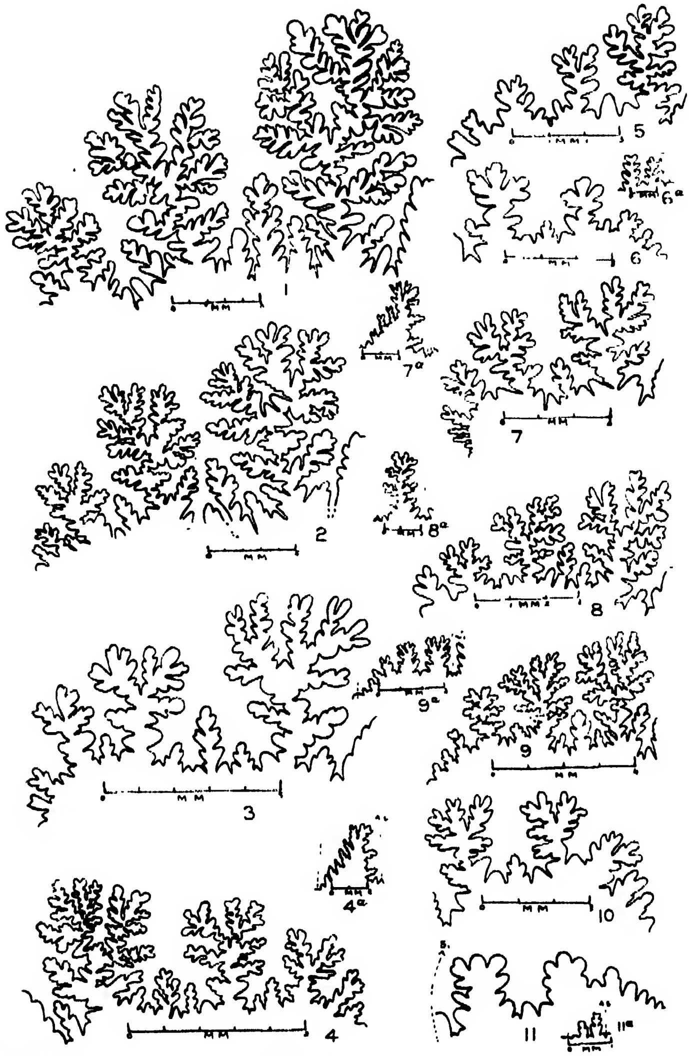
IMPORTANCE OF SUTURE-LINES.

The suture-lines that are represented in Plates 19–25 have been drawn with great care, and are thought to be nearly exact, though the projection on to a flat surface offers difficulty, and certainly gives rise to some error. As far as practicable, mechanical methods were employed, and errors in proportions are thereby greatly reduced. It is recognized that too much reliance cannot be placed on the details of the form of the suture-line for purposes of identification: ornamentation and proportions of the shell must have full consideration.



Suture-lines of the following species:—

FIG. 1.—*Baculites rectus* n. sp. Bull's Point.
FIG. 2.—*Ptychoceras zelandicum* n. sp. Whangaroa.
FIG. 3.—*Diplomoceras wakanene* n. sp. Bull's Point.
FIG. 4.—*Phylloceras nera* Forbes. H. 19; W. 9. Batley.
FIG. 5.—*Phylloceras bistriatum* n. sp. H. 19; W. 19. Bull's Point.
FIG. 5a.—Internal suture-line.
FIG. 6.—*Phylloceras forbesianum* d'Orb. H. 17; W. 16·5. Batley.
FIG. 7.—*Phylloceras radiatum* n. sp. H. 22; W. 15. Bull's Point.
FIG. 7a.—Internal suture-line.
FIG. 8.—*Phylloceras minimum* n. sp. H. 10·5; W. 9.
FIG. 8a.—Internal suture-line.
FIG. 9.—*Zelandites kaiparaensis* n. sp. H. 7·6; W. 6. Bull's Point.
FIG. 9a.—Internal suture-line.
FIG. 10.—*Schluteria rarawa* n. sp. H. 4·75; W. 5·25. Batley.



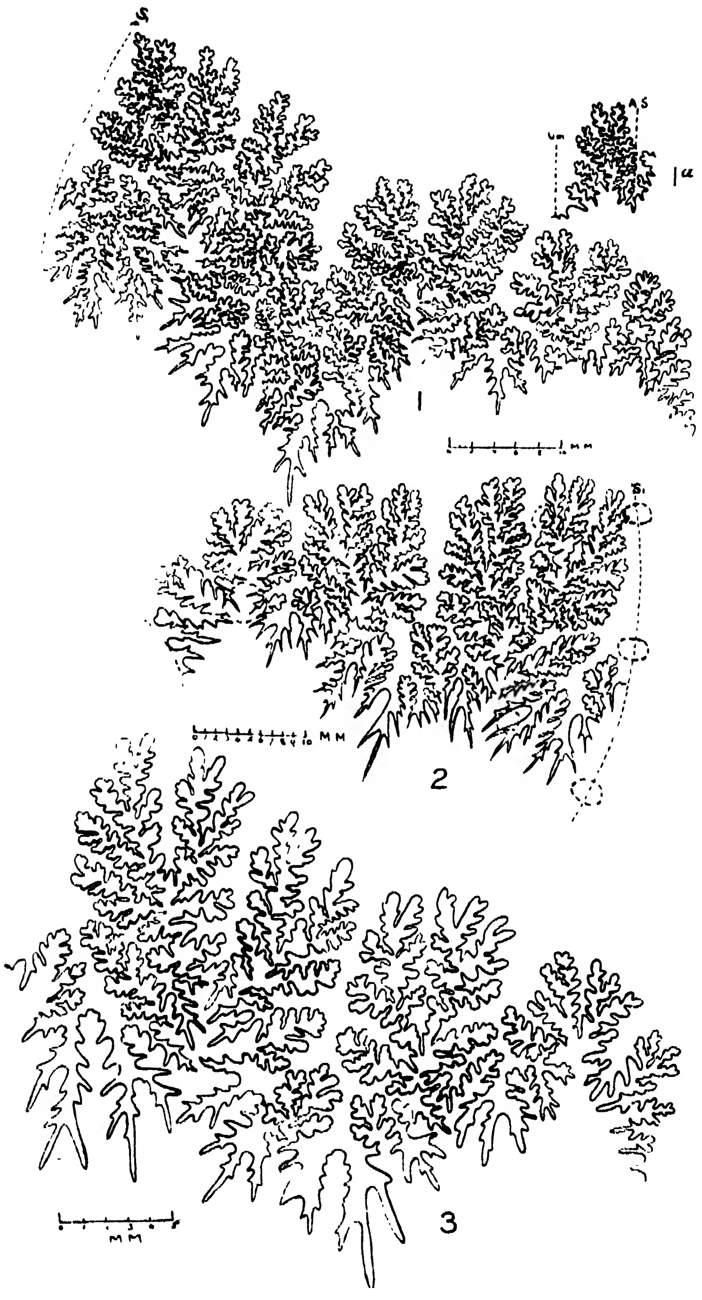
Suture-lines of the following species :—

FIG. 1.—*Pseudophyllites indra* Forbes. H. 22; W. 21. Bull's Point.
FIG. 2.—*Pseudophyllites whangaroaensis* n. sp. H. 16; W. 18. Whangaroa.
FIG. 3.—*Gaudryceras politissimum* Koss. H. 9; W. 7·5. Bull's Point.
FIG. 4.—*Gaudryceras propemite* n. sp. H. 7; W. 9.
FIG. 4*a*.—Internal portion of suture-line. Bull's Point.
FIG. 5.—*Tetragonites margaritatus* n. sp. H. 5·5; W. 6·25. Batley.
FIG. 6.—*Tetragonites latus* n. sp. H. 6·25; W. 10. Batley.
FIG. 6*a*.—Internal portion of suture-line. H. 4; W. 8.
FIG. 7.—*Gaudryceras particostatum* n. sp. H. 7; W. 6·5. Bull's Point.
FIG. 7*a*.—Internal portion of suture-line. H. 8; W. 8.
FIG. 8.—*Gaudryceras subsacya* n. sp. H. 5; W. 7·5.
FIG. 8*a*.—Internal portion of suture-line. H. 7; W. 9.
FIG. 9.—*Vertebrites murdochi* n. sp. H. 5; W. 10. Hokianga.
FIG. 9*a*.—Internal portion of suture-line.
FIG. 10.—*Gaudryceras crenatum* n. sp. H. 4·75; W. 6·5. Bull's Point.
FIG. 11.—*Tetragonites simplex* n. sp. H. 5·75; W. 5·5. Batley.
FIG. 11*a*.—Internal portion of suture-line. H. 3; W. 3.

Suture-lines of the following species :—

Fig. 1.—*Jacobites whangaroaensis* n. sp. H. 44 ; W. 35. Whangaroa.
Fig. 2.—*Jacobites angularis* n. sp. H. 21 ; W. 22·5. Bull's Point.
Fig. 3.—*Jacobites anderssoni* K. & R. H. 12 ; W. 11.
Fig. 3*a*.—Internal portion of suture-line. H. 5 ; W. 5.
Fig. 4.—*Neomadrasites nodulosus* n. sp. H. 7·5 ; W. 9·25. Bull's Point.
Fig. 4*a*.—Internal portion of suture-line.
Fig. 5.—*Jacobites minimum* n. sp. H. 3 ; W. 2·2. Batley.
Fig. 6.—*Madrasites multicostatus* n. sp. H. 9·5 ; W. 10. Bull's Point.
Fig. 7.—*Madrasites regularis* n. sp. H. 10 ; W. 10. Bull's Point.
Fig. 8.—*Gunnarites nordenskjoldi* K. & R. H. 5 ; W. 5. · Batley.
Fig. 9.—*Brahmaites rotundus* n. sp. H. 5 ; W. 8. Batley.
Fig. 10.—*Tetragonites tetragonus* Koss. H. 16 ; W. 17. Bull's Point.
Fig. 11.—*Pseudophyllites whangaroaensis* n. sp. Internal portion of suture-line. H. 6·5 ; W. 7·5. Whangaroa.
Fig. 12.—*Madrasites fortior* n. sp. Whangaroa.

Suture-lines of the following species:—
FIG. 1.—*Gunnarites inflatus* K. & R. H. 38; W. 32. Batley.
FIG. 1a.—Internal portion of suture-line. H. 35; W. 31. Bull's Point.
FIG. 1b.—Suture-line of juvenile form. Bull's Point.
FIG. 2.—*Gunnarites zelandicus* Marshall. H. 24; W. 22. Specimen somewhat eroded.
FIG. 3.—*Gunnarites antarcticus* Stuart Weller. H. 35; W. 27. Batley.
FIG. 4.—Internal suture-line of *Jacobites angularis* n. sp. H. 21; W. 25.
FIG. 5.—*Puzosia angusta* n. sp. H. 25; W. 9.



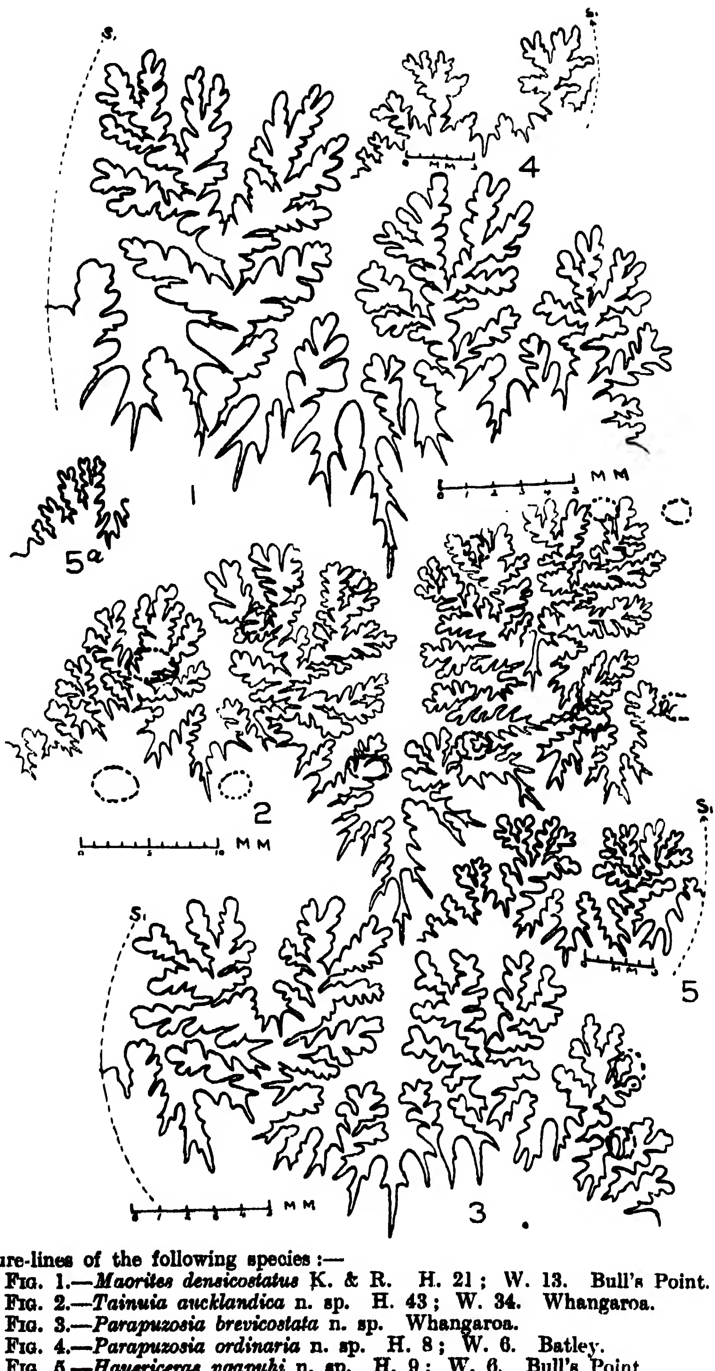
Suture-lines of the following species:—

FIG. 1.—*Maorites tenuicostatus* Marshall. H. 51; W. 35·5. Batley.

FIG. 1a.—Internal portion of suture-line. H. 39; W. 35.

FIG. 2.—*Jacobites waitapuensis* n. sp. H. 34; W. 30. Whangaroa.

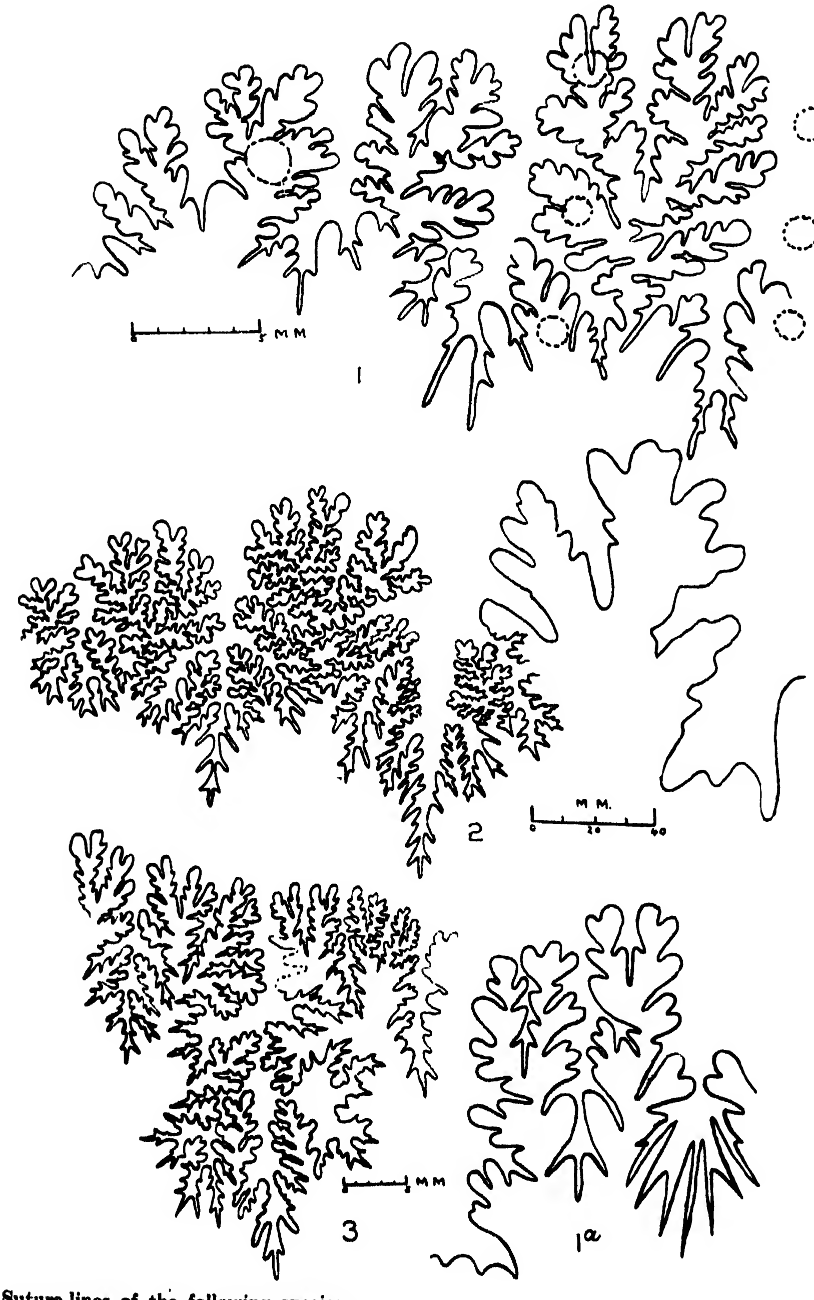
FIG. 3.—*Maorites suturalis* n. sp. H. 26; W. 17. Bull's Point.



Suture-lines of the following species :—

Fig. 1.—*Maorites densicostatus* K. & R. H. 21 ; W. 13. Bull's Point.
Fig. 2.—*Tainuia aucklandica* n. sp. H. 43 ; W. 34. Whangaroa.
Fig. 3.—*Parapuzosia brevicostata* n. sp. Whangaroa.
Fig. 4.—*Parapuzosia ordinaria* n. sp. H. 8 ; W. 6. Batley.
Fig. 5.—*Hauericeras ngapuhi* n. sp. H. 9 ; W. 6. Bull's Point.
Fig 5a.—Internal portion of suture-line.

(Through an unfortunate error tubercles are indicated in fig. 3 in place of fig. 1.)



Suture-lines of the following species :—

Fig. 1.—*Acanthoceras ultimum* n. sp. Bull's Point.

Fig. 1a.—Internal portion of suture-line. H. 9.

Fig. 2.—*Parapachydiscus rogeri* n. sp. H. 220 ; W. 270 (?). Bull's Point.

Fig. 3.—*Nowakites denticulatus* n. sp. H. 39 ; W. 38 (?). Bull's Point.

PLATE 26

FIG. 1.—*Phylloceras nera* Forbes. × 1½.
FIG. 2.—*Phylloceras nera* Forbes: section from periphery to umbilicus.
FIG. 3.—*Phylloceras radiatum* n. sp. × 1½.
FIG. 4.—*Phylloceras radiatum* n. sp.: section from periphery to umbilicus.
FIG. 5.—*Phylloceras minimum* n. sp. Bull's Point. × 2½.
FIG. 6.—*Phylloceras minimum* n. sp.: section.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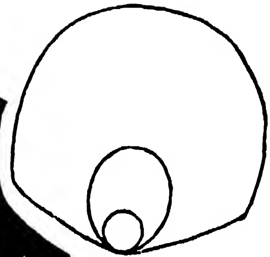
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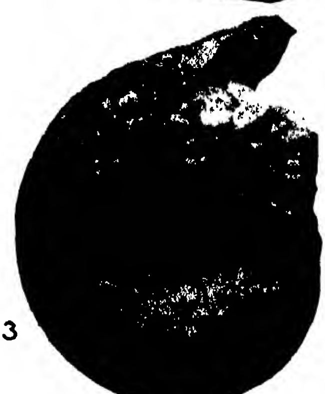
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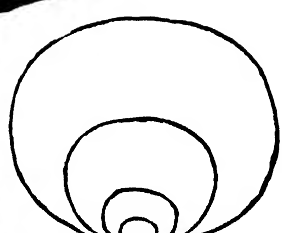
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Fig. 1.—*Phylloceras bistriatum* n. sp. Bull's Point. × 2.
Fig. 2.—*Phylloceras bistriatum* n. sp.: section.
Fig. 3.—*Phylloceras forbesianum* d'Orb. × 2.
Fig. 4.—*Phylloceras forbesianum* d'Orb.: section.

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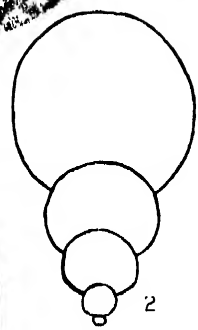

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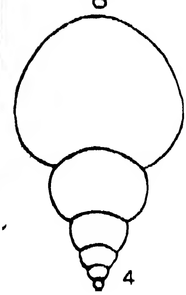

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FIG. 1.—*Gaudryceras politissimum* Koss. Batley. × 1½
FIG. 2.—*Gaudryceras politissimum* Koss.: section.
FIG. 3.—*Gaudryceras propemite* n. sp. Bull's Point. × 1½.
FIG. 4.—*Gaudryceras propemite* n. sp.: section.

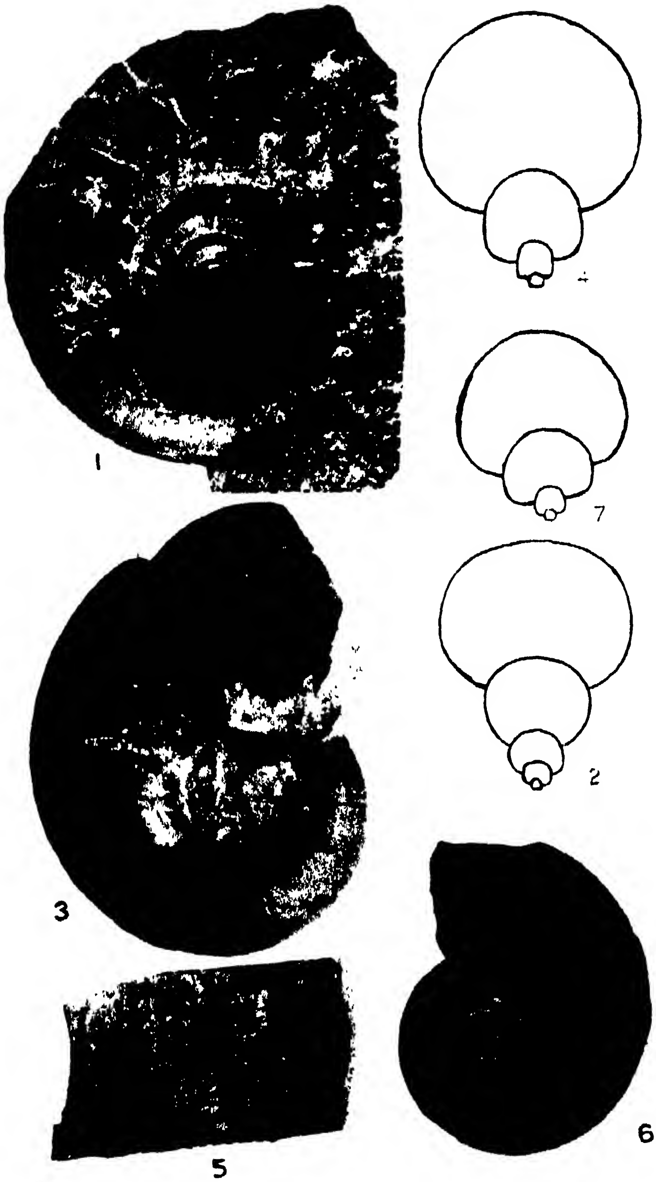
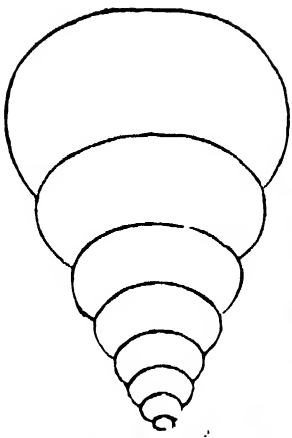


FIG. 1.—*Gaudryceras subsacya* n. sp. Bull's Point. × 1½.
FIG. 2.—*Gaudryceras subsacya* n. sp.: section.
FIG. 3.—*Pseudophyllites indra* Forbes. × 1½.
FIG. 4.—*Pseudophyllites indra* Forbes: section.
FIG. 5.—*Pseudophyllites indra* Forbes: flank, showing suture-line.
FIG. 6.—*Tetragonites epigonus* Koss. × 1½.
FIG. 7.—*Tetragonites epigonus* Koss.: section.



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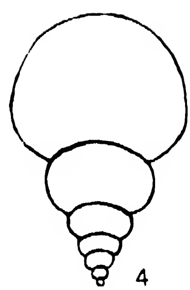

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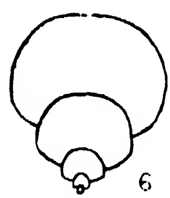

6

FIG. 1.—*Vertebrites murdochi* n. sp. × 1½.
FIG. 2.—*Vertebrites murdochi* n. sp.: section.
FIG. 3.—*Gaudryceras particostatum* n. sp. × 1½.
FIG. 4.—*Gaudryceras particostatum* n. sp.: section.
FIG. 5.—*Tetragonites margaritatus* n. sp. × 1½.
FIG. 6.—*Tetragonites margaritatus* n. sp.: section.

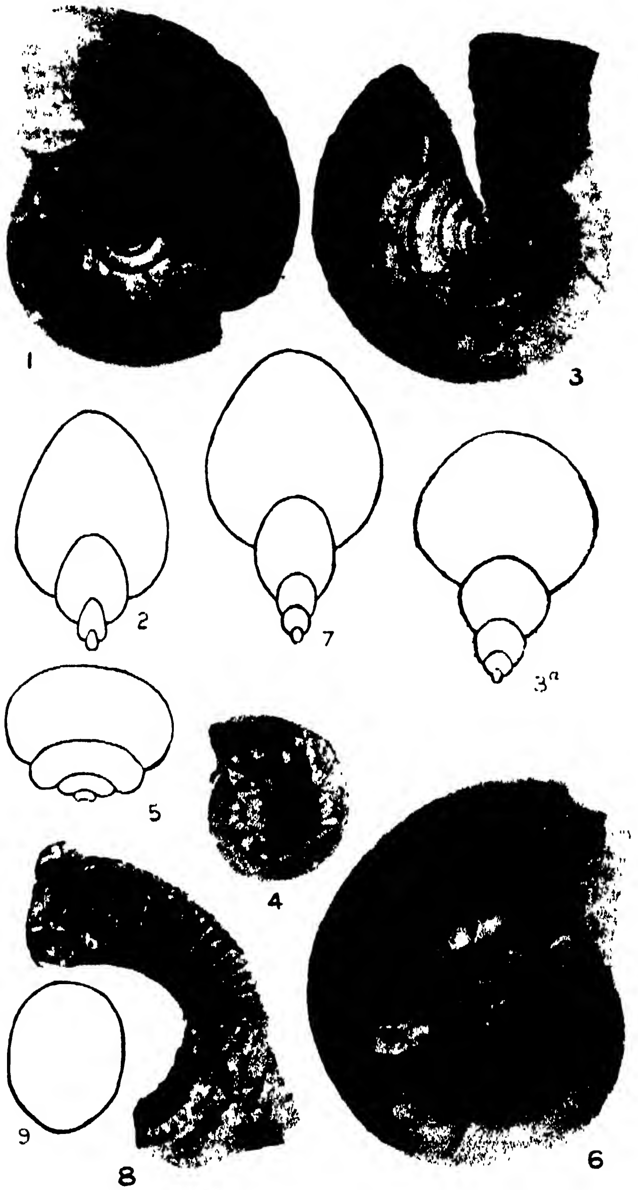

FIG. 1.—*Zelandites kaiparaensis* n. sp. Bull's Point. × 1½.
FIG. 2.—*Zelandites kaiparaensis* n. sp.: section.
FIG. 3.—*Gaudryceras crenatum* n. sp. Bull's Point. × 1½.
FIG. 3a.—*Gaudryceras crenatum* n. sp.: section.
FIG. 4.—*Brahmaites rotundus* n. sp. Batley. × 1½.
FIG. 5.—*Brahmaites rotundus* n. sp.: section.
FIG. 6.—*Parapuzosia ordinaria* n. sp. Batley. × 1½.
FIG. 7.—*Parapuzosia ordinaria* n. sp.: section.
FIG. 8.—*Diplomoceras wakanene* n. sp. Bull's Point. × 1½.
FIG. 9.—*Diplomoceras wakanene* n. sp.: section.

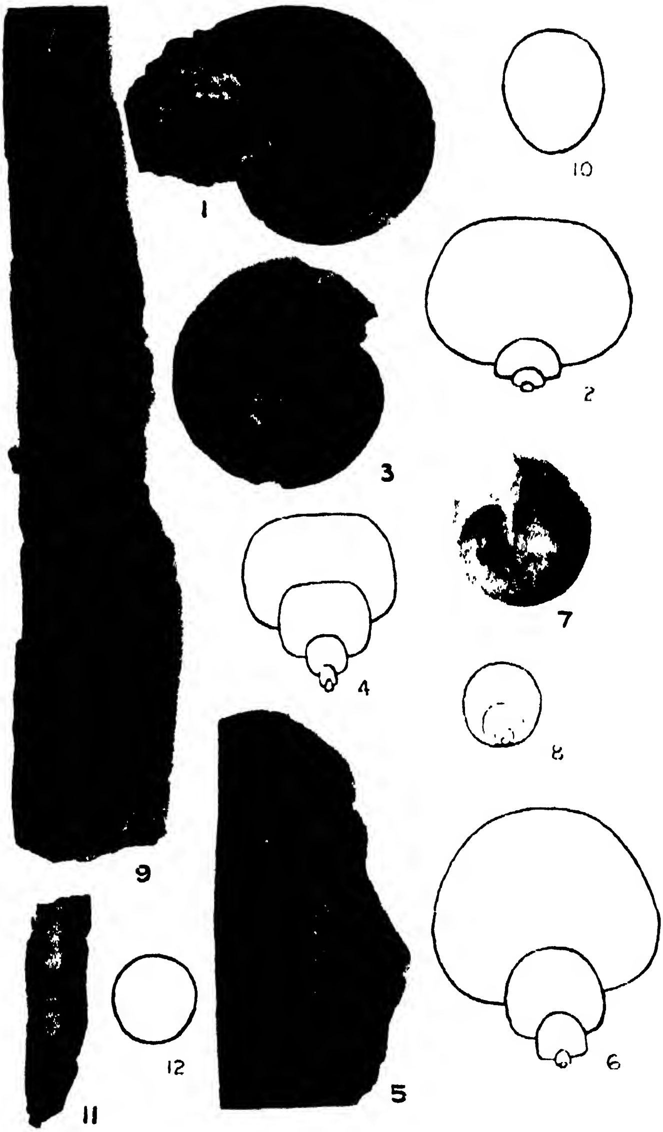

Fig. 1.—*Tetragonites latus* n. sp. Batley. × 1½.
Fig. 2.—*Tetragonites latus* n. sp.: section.
Fig. 3.—*Tetragonites simplex* n. sp. Bull's Point. × 1½.
Fig. 4.—*Tetragonites simplex* n. sp.: section.
Fig. 5.—Periphery of *Pseudophyllites whangaroaensis* n. sp., showing sculpture.
Fig. 6.—*Pseudophyllites whangaroaensis* n. sp.: section.
Fig. 7.—*Schluteria rarawa* n. sp. Batley. × 1½.
Fig. 8.—*Schluteria rarawa* n. sp.: section.
Fig. 9.—*Baculites rectus* n. sp. Batley. × 1½.
Fig. 10.—*Baculites rectus* n. sp.: section.
Fig. 11.—*Ptychoceras zelandicum* n. sp. Bull's Point. × 1½.
Fig. 12.—*Ptychoceras zelandicum* n. sp.: section.

Orybeloceras sp. Mangamuka River. Hokianga. × $\frac{3}{4}$.

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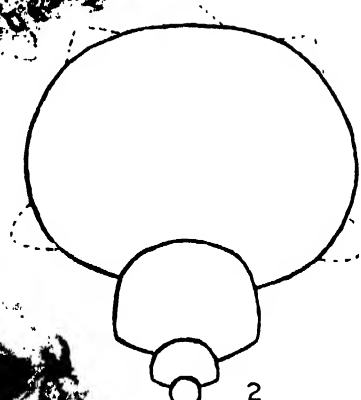

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FIG. 1.—*Acanthoceras ultimum* n. sp. Bull's Point. × 1¼.
FIG. 2.—*Acanthoceras ultimum* n. sp.: section.
FIG. 3.—*Tainuia aucklandica* n. sp.: showing development of tubercles. × 1¼.

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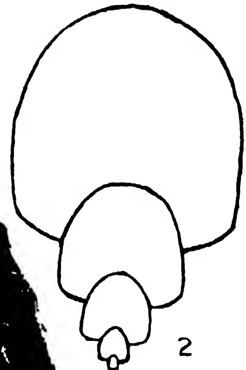

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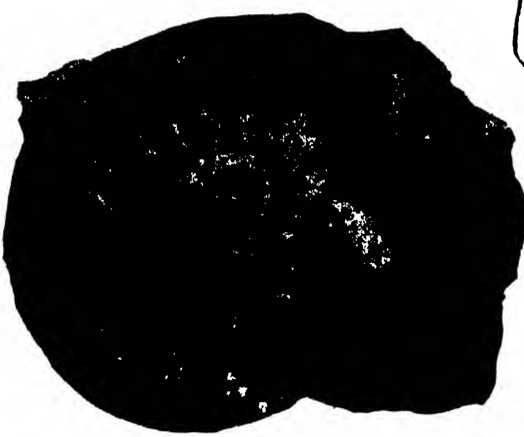

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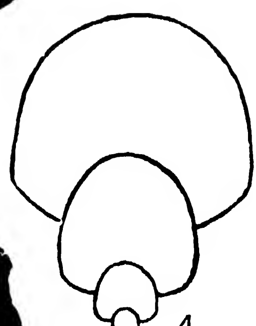

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Fig. 1.—*Madrasites multicostatus* n. sp. Bull's Point. × 2.
Fig. 2.—*Madrasites multicostatus* n. sp.: section.
Fig. 3.—*Madrasites regularis* n. sp. Bull's Point. × 2.
Fig. 4.—*Madrasites regularis* n. sp.: section.

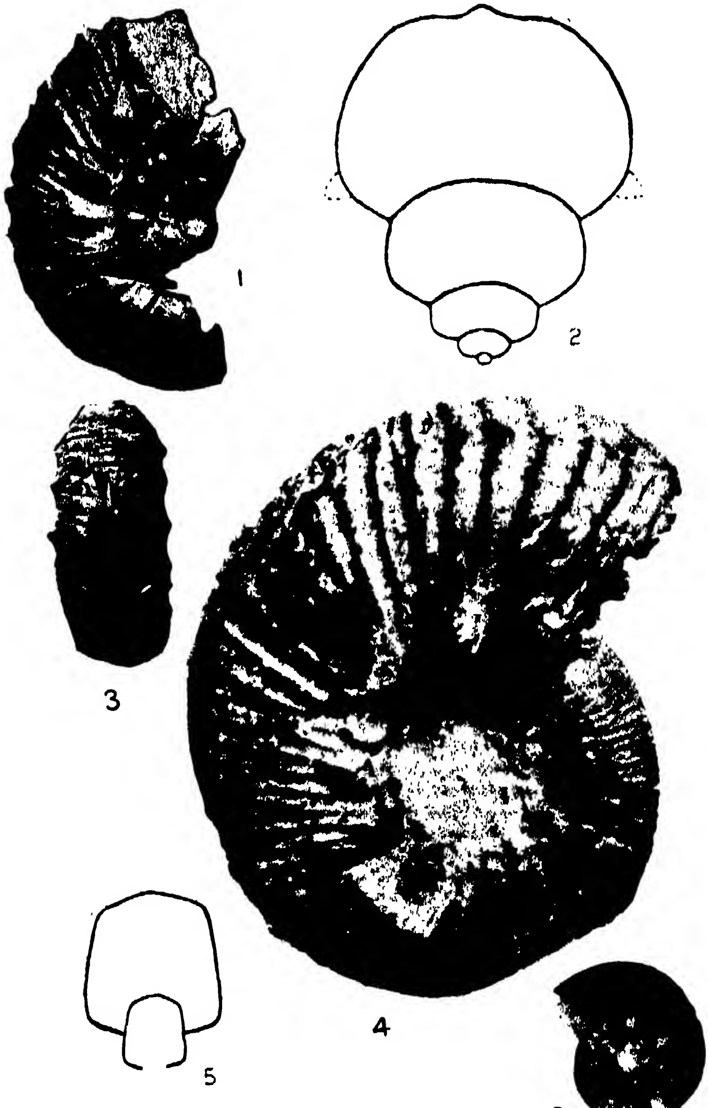

FIG. 1.—*Neomadrasites nodulosus* n. sp. Bull's Point. × 1½.
FIG. 2.—*Neomadrasites nodulosus* n. sp.: section.
FIG. 3.—*Neomadrasites nodulosus* n. sp.
FIG. 4.—*Jacobites angularis* n. sp.: Bull's Point. × 1½.
FIG. 5.—*Jacobites angularis* n. sp.: section.
FIG. 6.—*Gunnarites nordenskjoldi* K. & R. Batley. × 1½.

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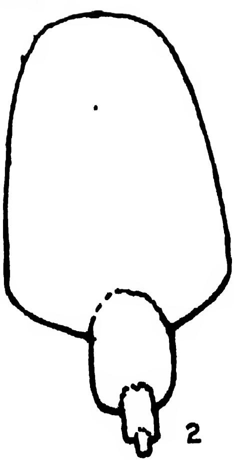

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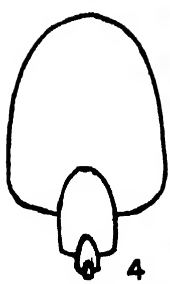

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FIG. 1.—*Jacobites whangaroaensis* n. sp. Whangaroa. × ½.
FIG. 2.—*Jacobites whangaroaensis* n. sp.: section.
FIG. 3.—*Jacobites anderssoni* K. & R. Bull's Point. × 1½.
FIG. 4.—*Jacobites anderssoni* K. & R.: section.

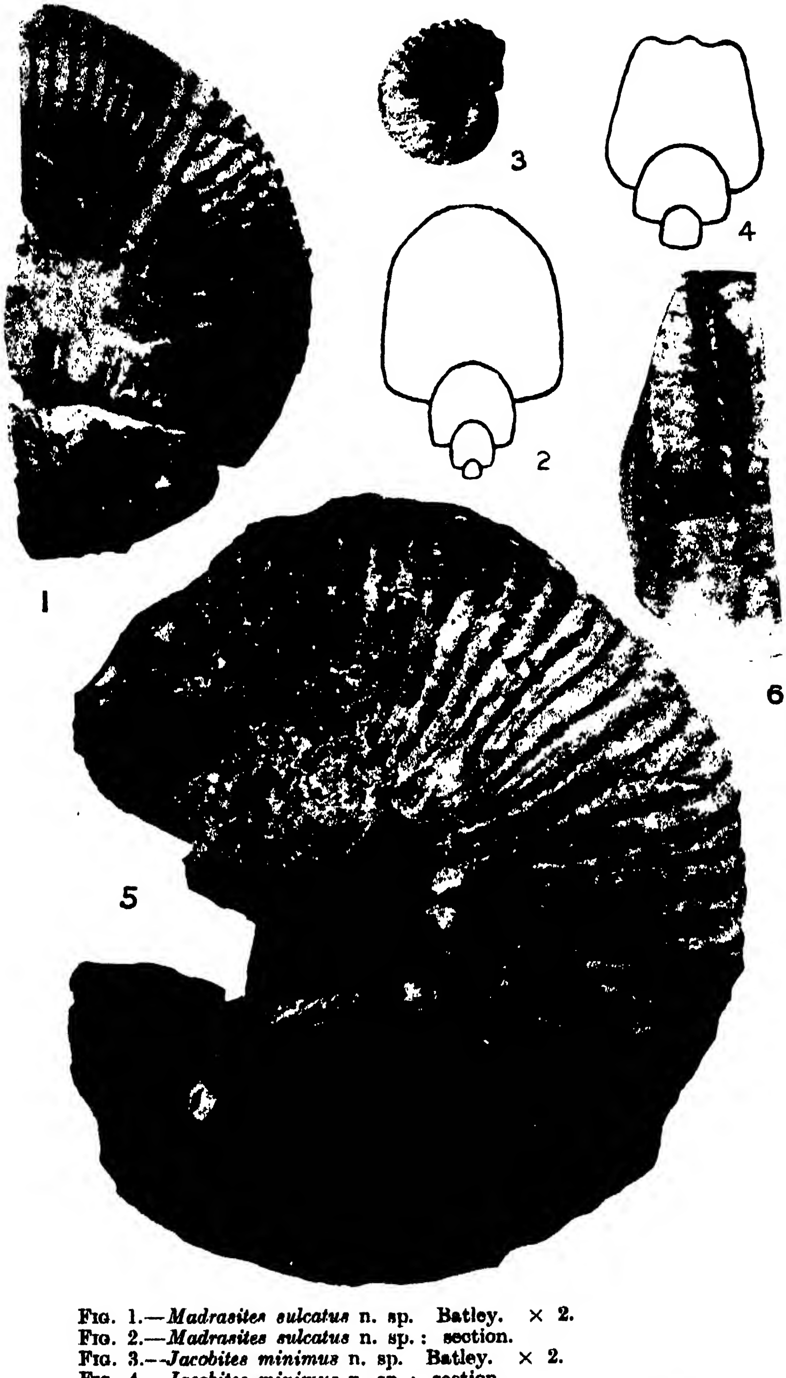
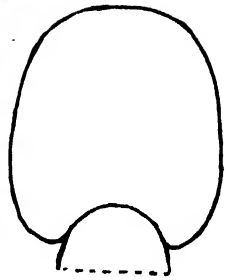


FIG. 1.—*Madrasites sulcatus* n. sp. Batley. × 2.
FIG. 2.—*Madrasites sulcatus* n. sp.: section.
FIG. 3.—*Jacobites minimus* n. sp. Batley. × 2.
FIG. 4.—*Jacobites minimus* n. sp.: section.
FIG. 5.—*Nowakites denticulatus* n. sp. Bull's Point. Nat. size.
FIG. 6.—*Nowakites denticulatus* n. sp.: showing costation. × 2.

1



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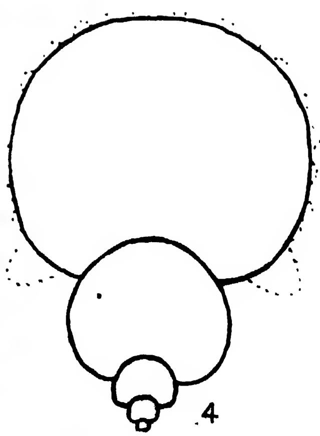
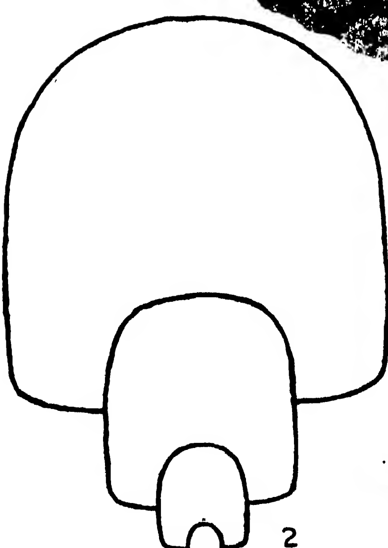


4

FIG. 1.—*Gunnarites zelandicus* Marshall. Batley. × 1¼.
FIG. 2.—*Gunnarites zelandicus* Marshall: section.
FIG. 3.—*Gunnarites antarcticus* Stuart Weller. Bull's Point. × 1¼.
FIG. 4.—*Gunnarites antarcticus* Stuart Weller: section.

1



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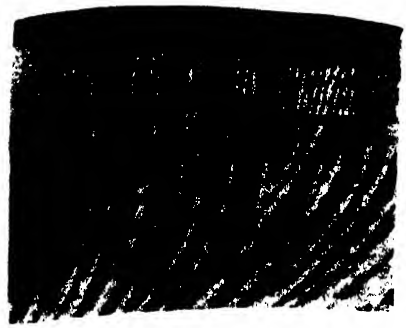

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Fig. 1.—*Gunnarites inflatus* K. & R. Batley. Nat. size.
Fig. 2.—*Gunnarites inflatus* K. & R.: section.
Fig. 3.—Flank of *Vertebrites murdochi* n. sp., showing change in costation. × 5.

1

3

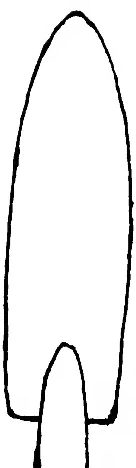

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FIG. 1.—*Puzosia angusta* n. sp.: showing costation. Bull's Point. × 2.
FIG. 2.—*Puzosia angusta* n. sp.: section.
FIG. 3.—*Madrasites fortior* n. sp. Whangaroa. × 2.
FIG. 4.—*Madrasites cumshewaensis?* Whiteaves. Whangaroa. × 2.

1

2

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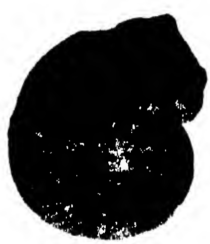

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FIG. 1.—*Maorites tenuicostatus* Marshall. Batley. Nat. size.
FIG. 2.—*Maorites tenuicostatus* Marshall (juv.). Bull's Point. ×
FIG. 3.—*Maorites densicostatus* K. & R. (juv.). Bull's Point.
FIG. 4.—*Maorites suturalis* n. sp. (juv.). Bull's Point. × 2.

1

2

3

Fig. 1.—*Maorites suturalis* n. sp. Bull's Point. × 1¼.
Fig. 2.—*Parapuzosia brevicostata* n. sp. Whangaroa. × 2,
Fig. 3.—*Hauericeras ngapuhi* n. sp. Bull's Point. × 2.

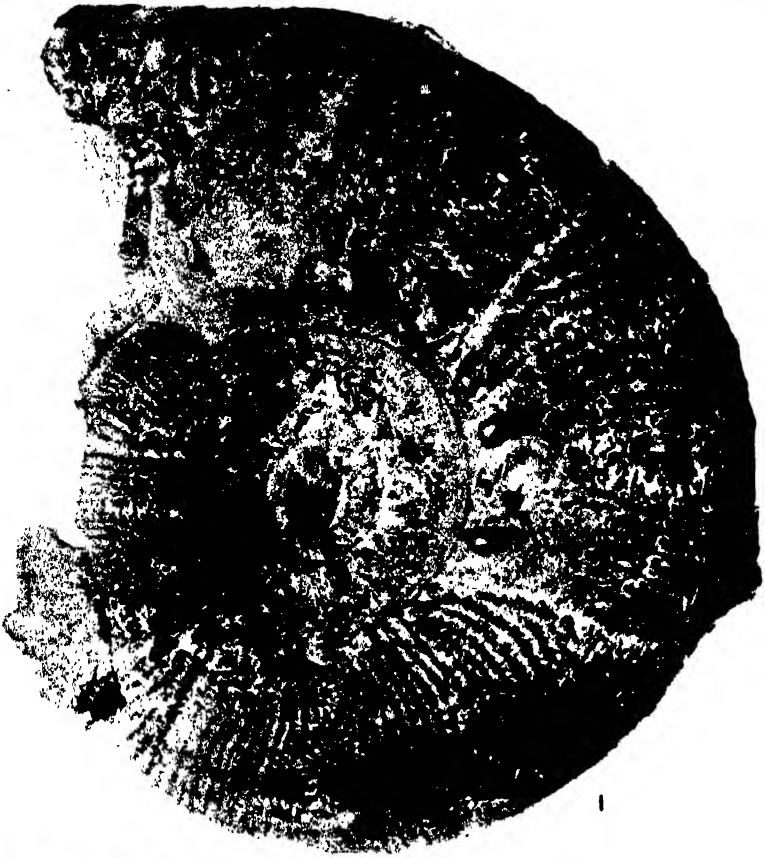

Fig. 1.—*Jacobites waitapuensis* n. sp. Whangaroa. × 1¼.
Fig. 2.—*Maorites densicostatus* K. & R. Bull's Point. Nat. size.

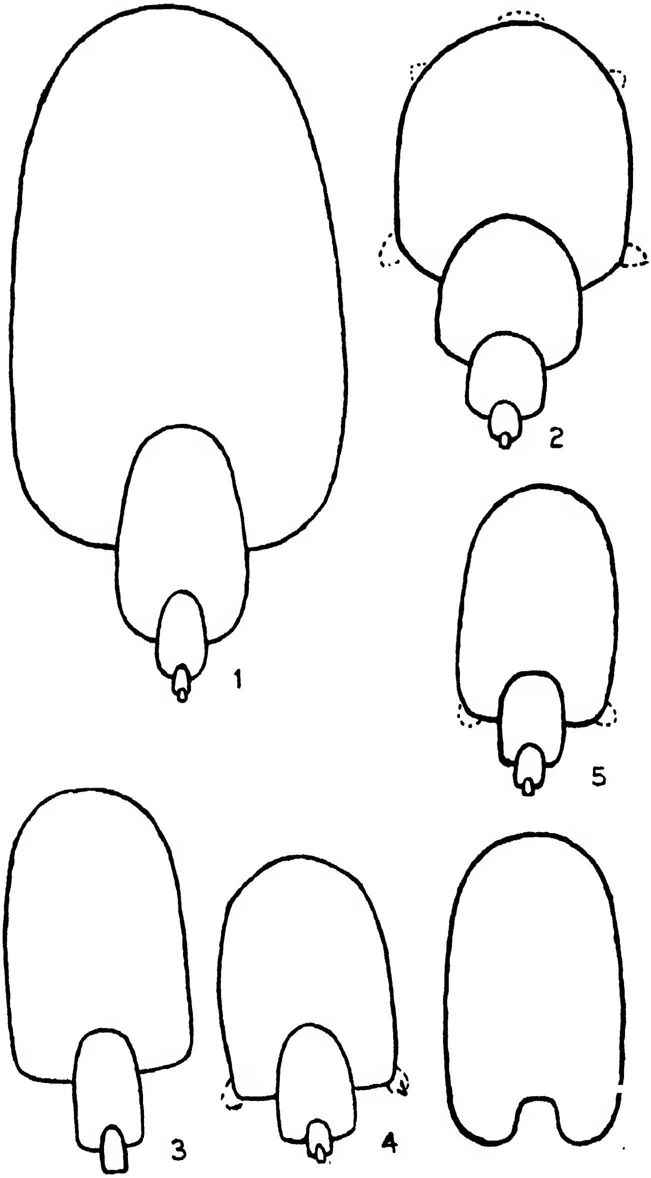

FIG. 1.—*Maorites tenuicostatus* Marshall: section.
FIG. 2.—*Jacobites waitapuensis* n. sp.: section.
FIG. 3.—*Hauericeras ngapuhi* n. sp.: section.
FIG. 4.—*Maorites densicostatus* K. & R.: section.
FIG. 5.—*Maorites suturalis* n. sp.: section.
FIG. 6.—*Parapuzosia brevicostata* n. sp.: section.

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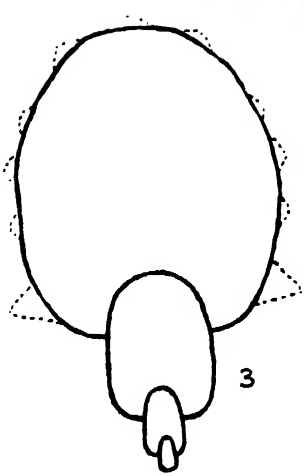

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2

FIG. 1.—*Tainuia aucklandica* n. sp. Whangaroa. Nat. size.
FIG. 2.—*Tainuia aucklandica* n. sp.: fragment showing ornamentation. × 1½.
FIG. 3.—*Taunuia aucklandica* n. sp.: section.

1

2

FIG. 1.—*Parapachydiscus rogeri* n. sp. Bull's Point. $\times \frac{1}{3}$.
FIG. 2.—*Parapachydiscus rogeri* n. sp.: showing costation. $\times$

So far as this collection is concerned, it has been found that the suture-line in nearly all cases has given clear indication of the generic position that a species should have, though it hardly enables one to distinguish between such genera as *Madrasites*, *Jacobites*, and *Gunnarites*. It is thought that the time that has been taken in drawing these lines in detail has not been wasted.

It seems that little attention has hitherto been given to the nature of the internal portion of the suture-line. In few researches on collections of ammonites have any drawings been made of them. So far as can be ascertained, Kossmat is the only author who has made any use of them for purposes of classification, and he appears to have done so in one instance only—in the distinction between *Gaudryceras* and *Tetragonites*.

In this paper drawings of the internal suture-line of several species will be found, and it is suggested that the form of it may be of great use in assigning species to their proper position in doubtful cases. Spath, however, attaches little or no importance to it: "The stretching-out of the auxiliary elements may only be the result of the adaptation of the suture-line to wider sides, and the raising of the umbilical portion is often found in younger developments" (53, p. 239). This, however, does not hold generally: compare, for example, *Gaudryceras* and *Pseudophyllites*.

The form of the internal suture-line is little varied in time and in the widely scattered species of a genus. The internal suture-line of a species of *Phylloceras* from the Dogger (Zittel, *Handbuch*, vol. 2, fig. 609) differs but little from those of New Zealand specimens from the Upper Cretaceous. The difference is almost restricted to a reduction in the number of saddles. It is certainly striking that the New Zealand species have the same number of saddles as in *Sowerbyceras*, and the suggestion thus offered that the New Zealand species should be placed in the latter genus is supported by some other details. Further material for study is, however, needed.

The genus *Gaudryceras* has the same unusual form of this suture-line in species from India, Japan, South Africa, and New Zealand. The importance of this line that is here suggested is supported by the great variety of form that it presents.

A summary of the variations that have been found in these New Zealand specimens is considered worthy of a special statement:—

Phylloceras: Internal saddle club-shaped. Two lateral saddles, the second with an almost spherical termination. No auxiliaries.

Gaudryceras: A single saddle of uniform width, which is typical in *G. subsacya*. Those species of *Gaudryceras*, such as *G. semileve*, which have a single saddle, increasing greatly in width at the base, should perhaps be placed in a separate genus.

Tetragonites: Two well-developed saddles, as in *T. epigonus*. Such a species as *T. simplex* has an additional saddle.

Pseudophyllites: Two saddles, the external one with much greater development than the first lateral.

Vertebrites: Five or six saddles, gradually decreasing in size towards the umbilicus.

Zelandites: A single saddle, wide at the base.

Jacobites and *Gunnarites* both have two large saddles, which in the latter genus are much dissected; the antisiphonal lobe is very deep. This form appears to indicate a descent from *Acanthoceras.*

Madrasites, so far as the New Zealand specimens are concerned, has an internal suture-line but little different from *Jacobites*, and thus differs much from that figured by Kossmat.

The suture-line of *Pachydiscus* as drawn by Yabe is quite different from those of the genera mentioned, but it could not be seen in any of the New Zealand specimens.

Maorites, *Puzosia*, and *Haueriveras* have the same type of internal suture-line. The lateral saddles and the auxiliaries are situated on the outer slope of the internal saddle, and thus give the appearance of a single complex much-divided saddle. This type of internal suture-line appears as far back as *Dalmasiceras*, and is continued in *Perisphinctes*, and is supposed to indicate a relationship to the Hoplitid stock. It is much regretted that the material that was available did not allow of further study.

GEOGRAPHICAL RELATIONSHIP.

In order to make it possible to draw any geographical conclusions from the distribution of the species of ammonites that have been found in New Zealand it is necessary to summarize the facts that have already been recorded in regard to their occurrence in different circum-Pacific countries.

The following percentages of the ammonite fauna of the various countries are represented in New Zealand by identical or closely allied species:—

—	Number of Species.	Number of Related Species in N.Z.	Percentage of Species in N.Z.	Percentage of N.Z. Species in each.
Aryalur	53	18	34	34
Trichinopoly	26	4	15·5	8
Utatur	89	11	12·5	20
Seymour Island	41	16	39	31
South Patagonia ..	20	2	10	4
Quiriquina	10	5	50	10
Chico	52	7	13	14
Nanaimo	17	2	11	14
Queen Charlotte Island ..	27	7	8	4
Japan	47	10	21	19
New Caledonia	12	4	33	8
Pondoland	54	12	22	22
Madagascar	49	5	10	10

It is unfortunate that the Upper Cretaceous ammonites of New Caledonia have not been more fully collected and identified, though Piroutet has done excellent work. The fauna that has been collected by him suggests

that it is rather similar to that of New Zealand, but in the meantime this statement is somewhat hazardous.

As shown in this table, the Seymour Island fauna has remarkable similarities with that of New Zealand, and the conclusion is suggested that there was a continuous coast-line between these countries. This is the belief of Wilckens and others. On the other hand, the Patagonian fauna contains the *Hoplites-Placenticeras* elements that are absent from New Zealand, Antarctica, and Chile, and in this last country the small fauna that has been discovered shows a closer resemblance to that of New Zealand than any other that has been recorded. No country between Chile and California has yet yielded an Upper Cretaceous ammonite fauna, but in the latter there is the well-known Chico formation. In the lower series of this formation there is a fairly rich fauna, but it is not closely related to that of New Zealand. In the Upper Chico series there are fewer ammonites, and they show a closer resemblance than those of the lower series.

In British Columbia the Queen Charlotte Islands have yielded a fauna that has little resemblance to the one described in this paper, but it is probably of Middle Cretaceous age. On the other hand, the Nanaimo beds are of the Upper Cretaceous period, but still the species that have been obtained from them show little similarity, on the whole, to the New Zealand species.

In the highest Upper Cretaceous ammonite-bearing strata of South India—that is, the Aryalur—a close relationship with New Zealand is again displayed; but in the beds below them—the Trichinopoly series of Lower Senonian age—the resemblance is much less pronounced, and the specific resemblances are fewer. The Utatur beds, which are considered to be of Cenomanian age, have also several species that are closely related to New Zealand forms. The amount of resemblance is, however, decidedly less in the lower than in the upper series.

I have no access to a complete statement of the species that have been found in Madagascar. The works of Spath, Woods, and van Hoepen give full information of the ammonite fauna of Pondoland. It is rather remarkable that these beds contain a fauna that is much more closely related to that of New Zealand than is the fauna of the beds of the same age at Umzamba Hill, in Zululand.

The general geographical impression that is produced is, as might be expected, that the ammonite fauna of this Upper Cretaceous age in the countries closer to New Zealand is more closely related than that of the countries that are more remote. Patagonia is, of course, a striking exception to the general application of this statement, while the species that have been found in Chile and New Caledonia are too few to allow of a satisfactory comparison.

TABLE SHOWING THE OCCURRENCE OF REPRESENTATIVE

	—	South Africa.	Madagascar.	India (Aryalur and Valudayur).	India (Trichinopoly).	India (Utatur).
1	*Phylloceras nera* Forbes	*P. woodsi* (Pondoland)	..	*P. nera*	..	..
2	*Phylloceras radiatum* n. sp.	*P. umsambiense*	*P. velledae* (Cenomanian)	..	..	*P. velledae*
3	*Phylloceras forbesianum* d'Orb.	..	*P. forbesianum* (Cenomanian)	..	..	*P. forbesianum*
4	*Phylloceras minimum* n. sp.	..	..	*P. whiteavesi*	..	..
5	*Phylloceras bistriatum* n. sp.	..	..	..	..	..
6	*Vertebrites murdochi* n. sp.	..	..	*G. kayei*	..	..
7	*Gaudryceras propemite* n. sp.*	*G. cintum* (Pondoland)	*G. multiplexum* (Coniacian)	..	..	*G. multiplexum*
8	*Gaudryceras particostatum* n. sp.	*G. varicostatum* (Pondoland)	..	..	..	..
9	*Gaudryceras subsacya* n. sp.	..	..	..	..	*G. sacya*
10	*Gaudryceras politissimum* Koss.	..	..	..	*G. politissimum*	*G. politissimum*
11	*Tetragonites epigonus* Koss.	*T. virgulatus* (Pondoland)	*T. epigonus* (Cenomanian)	..	*T. epigonus*	..
12	*Tetragonites latus* n. sp.	*T. superstes* (Pondoland)	..	..	..	*T. timotheanus*
13	*Tetragonites simplex* n. sp.	*T. nuperus*	..	*T. cala*	..	..
14	*Tetragonites margaritatus* n. sp.	*T. sigcau*	..	..	..	..
15	*Pseudophyllites indra* Forbes	*Ps. indra*	*Ps. indra*	*Ps. indra*	..	..
16	*Baculites rectus* n. sp.	..	..	(*B. vagina*)	..	..
17	*Diplomoceras wakanene* n. sp.	..	..	*D. rugatum*	..	..
18	*Ptychoceras zelandicum* n. sp.	..	..	*Pt. sipho*	..	..
19	*Acanthoceras ultimum* n. sp.†	..	*Ac. newboldi* (Cenomanian)	..	..	*Ac. newboldi*
20	*Madrasites regularis* n. sp.	(*M. africanus*)	..	..	..	(*M. muraviaturensis*)
21	*Madrasites multicostatus* n. sp.	..	..	..	*M. buddhaicus*	..
22	*Gunnarites antarcticus* St. Wel.	..	..	*G. kalika*	..	..
23	*Gunnarites zelandicus* Mar.	..	..	*G. kalika*	..	..
24	*Gunnarites inflatus* K. & R.	..	..	*G. kalika*	..	..
25	*Gunnarites nordenskjoldi* K. & R.	..	..	..	..	..
26	*Jacobites anderssoni* K. & R.	..	..	..	..	..
27	*Jacobites whangaroaensis* n. sp.	..	..	..	..	..
28	*Jacobites waitapuensis* n. sp.	..	..	..	..	..
29	*Brahmaites rotundus* n. sp.	..	*Brahmaites* sp.	*Brahmaites brahma*	..	..
30	*Maorites tenuicostatus* Mar.	..	..	? *M. bhavani*	..	..
31	*Maorites densicostatus* K. & R.	..	..	*M. aemilianus*	..	..
32	*Maorites suturalis* n. sp.	..	..	*M. baudi*	..	..
33	*Puzosia angusta* n. sp.	..	*P. compressa* (Cenomanian)	..	..	*P. compressa*
34	*Parapuzosia brevicostata* n. sp.	..	*P. gaudama* (Coniacian)	..	*P. gaudama*	..
35	*Parapuzosia ordinaria* n. sp.‡	..	..	..	..	*P. bhima*
36	*Tainuia aucklandica* n. sp.	..	*Ac. vicinale* (Cenomanian)	..	..	*Acanthoceras vicinale*
37	*Parapachydiscus rogeri* n. sp.	*P.* aff. *wittelkindi*	*P. tweenianus*	*P. tweenianus*	..	..
38	*Hauericeras ngapuhi* n. sp.	*H. gardeni*	*H. gardeni*	*H. gardeni*	..	..
39	*Schluteria rarawa* n. sp.	*S. compactum*	..	*S. diphylloides*	..	..
40	*Grossouvrites gemmatus* Huppé§	..	..	..	..	..
41	*Madrasites haumuriensis* Hect.‖	..	..	*M. bhavani*	..	..
42	*Turrilites circumtaeniatus* Koss.‖	..	..	..	..	*T. circumtaeniatus*
	Number of species in fauna	54	49	53	26	89
	Number of allied species in New Zealand	12	5	18	4	11

* Represented in Europe by *G. mite*, Lower Senonian.
† Represented in Europe by *Ac. rotomagense*, Cenomanian.
‡ Represented in Europe by *P. octosulcata*, Senonian.
§ Recorded by Trechmann, *Geol. Mag.*, dec. 6, vol. 4, p. 338, 1917.
‖ Recorded by Woods, *N.Z. Geol. Surv. Pal. Bull. No. 4*, 1917.

FORMS OF THE NEW ZEALAND AMMONITES.

Antarctica, Seymour Island, Snow Hill Island.	South Patagonia.	Chile (Quiriquina).	California.	Vancouver.	Japan.	New Caledonia.	
P. nera ..	*P. nera* ..	(*P. surya*) ..	..	..	..	..	1
P. ramosum ..	..	*P. ramosum* ..	*P. ramosum* ..	*P. velledae* ..	*P. velledae* ..	..	2
..	..	..	..	..	..	..	3
..	..	..	..	*P. whiteavesi*	..	..	4
..	..	..	..	..	*P. esoense* ..	..	5
G. kayei ..	..	*G. kayei* ..	*G. kayei* (Mt. Diablo)	*G. kayei* ..	..	..	6
G. multiplexum?	..	..	..	..	..	..	7
..	..	..	..	..	*G. tenuiliratum*	..	8
..	..	..	*G. sacya* ..	*G. sacya* ..	*G. sacya*, *G. tenuiliratum* var. *ornatum*	..	9
..	..	..	..	..	..	? *Gaudryceras*	10
T. epigonus ..	*T. epigonus* ..	..	..	..	*T.* afl. *epigonus*	*Tetragonites* sp.	11
..	..	..	*T. timotheanus*	*T. timotheanus*	*T. glabrus* ..	..	12
..	..	..	..	..	..	..	13
..	..	..	..	..	..	..	14
Ps. indra ..	..	..	*Ps. indra* ..	*Ps. indra* ..	..	..	15
..	..	..	*B. chicoensis*	*B. chicoensis*	..	? *Baculites* ..	16
..	..	..	..	..	..	? *Anisoceras*	17
..	..	..	*Pt. glaber* ..	..	..	..	18
..	..	..	*Ac. turneri* (Mt. Diablo)	..	..	*Ac. rotomagense*	19
..	..	..	..	..	..	..	20
? *M. cumshewaense*	..	..	? *M. cumshewaense*	..	..	? *M. cumshewaense*	21
G. antarcticus	..	..	..	..	..	..	22
G. antarcticus	..	..	..	..	..	..	23
G. inflatus	..	..	..	..	..	..	24
G. nordenskjoldi	..	..	..	..	..	..	25
J. anderssoni	..	..	..	..	..	..	26
? *J. anderssoni*	..	..	..	..	..	..	27
? *M. bhavani* var. *seymouriana*	..	..	..	..	..	..	28
..	..	..	..	..	..	? *M. bhavani*	29
? *M. bhavani* var. *densicostatus*	..	..	..	..	..	..	30
..	..	..	..	..	..	..	31
..	..	..	..	..	..	..	32
..	..	..	..	..	..	..	33
? *Puzosia* sp.	..	*P. darwini* ..	..	..	*P. gaudama* ..	? *P. gaudama*	34
..	..	..	..	..	..	..	35
..	..	..	..	..	*Ac. pseudo-deverianum*	..	36
..	..	*P. quiriquinae*	..	*Pachydiscus* sp.	*P. haradai*	..	37
H. gardeni ..	..	..	..	*H. gardeni* ..	*H. gardeni* ..	..	38
S. loryi ..	..	..	..	..	..	..	39
G. gemmatus	..	*G. gemmatus*	..	..	..	..	40
..	..	..	..	..	..	..	41
..	..	..	..	..	..	..	42
41 16	20 2	10 5	52 7	27+17 2 7	47 10	12 4?	

The following New Zealand species have no representatives in other countries: *Gaudryceras crenatum* n. sp., *Oxybeloceras* sp., *Madrasites sulcatus* n. sp., *M. fortior* n. sp., *Jacobites angularis* n. sp., *J. minimus* n. sp., *Neomadrasites nodulosus*, *Parapachydiscus denticulatus* n. sp., *Pseudophyllites whangaroaensis*. The following additional species have been recorded from New Zealand: (1) by Woods, *Gaudryceras sacya* Forbes (? *G. subsacya*), *G. baculites* cf. *vagina* (? *B. rectus*); (2) by Spath (53, p. 299), *Tetragonites* sp. (? *T. simplex*), *Kossmaticeras bhavani* Stol., K. [illegible] (?Whiteaves) K. & R., K. (Gu[illegible] K. & R.

GEOLOGICAL AGE OF CIRCUM-PACIFIC CRETACEOUS AMMONITE HORIZONS.

Whether all these faunas are strictly of the same age may well be doubted. Spath, for instance, says, "The chances then are that a fauna like that of Pondoland which does not quite agree with (*e.g.*) either the Upper Campanian of Galicia or the Valudayur of southern India, if homogeneous at all, may belong to a hitherto unrecognized horizon or horizons. Since non-sequences are possible, these horizons are, perhaps, not even consecutive" (54, p. 116). Paulcke also, in speaking of the Patagonian ammonites, says, "We find ourselves in this dilemma: Either we have to deal with Lower Senonian strata containing *Pachydiscus* which shows Upper Senonian characters, or we must suppose that the stratification is wrongly interpreted" (42A, p. 73). Wilckens, who described the lamellibranchs that were collected in the same beds as the ammonites, classes the strata that contain *Pachydiscus* in the Cenomanian or Turonian age, and thus supports the first alternative. (*Lamell. der oberen Kreide Sud-Pat.*, 1907, p. 60).

Kilian and Reboul, in their work on the ammonites of Seymour Island and Snow Hill, distinguish three different horizons, extending from Cenomanian to the Upper Senonian. Wilckens, however, in his work on the lamellibranchs and gasteropods of the same region, is emphatic that the collections from all of the localities indicate the same age, though he excepts from this statement the localities 2 and 6 of Snow Hill, whence nothing but ammonites was obtained. Wilckens concludes, "Ebenso wie die ubrige molluskan Fauna einheitlich ist. Sie ist obersenonisch. Die Hill Schichten für alter als die alteren Seymour Schichten zu halten liegt kein Grund vor; beide sind obersenonen."

It is thus apparent that those who have closely examined the faunas from Pondoland, Seymour Island, and Patagonia are at least in grave doubt about their actual age, or, at any rate, differ considerably in their opinions on this question. There is even doubt whether in any locality the strata represent more than one division of the Upper Cretaceous. A tabulated statement of the opinions that have been expressed in regard to the faunas that have been described from the Indo-Pacific countries will make this statement clearer.

Pondoland ..	Upper Campanian–Maestrictian	Spath, 54, p. 116.
	Upper Santonian ..	van Hoepen, 52, p. 45.
	Senonian	Woods, 40, p. 345.
Zululand ..	Campanian–Maestrictian	Spath, 53, p. 223.
Seymour Island and Snow Hill	Cenomanian – Upper Senonian	Kilian and Reboul, 46, p. 58.
	Upper Senonian	Wilckens, 47B, p. 114.
South Patagonia	Upper Senonian ..	Paulcke, 42A, pp. 72, 73.
	Cenomanian – Upper Senonian	Wilckens, 39, pp. 57–58.
Quiriquina	Upper Senonian ..	Steinmann, 26, p. 27.
	Upper Senonian ..	Wilckens, 38, p. 284.
California	Upper Chico = Lower Senonian	Anderson, 33, p. 62.
	Lower Chico = Turonian	Anderson, 33, p. 62.
Nanaimo	?	Whiteaves.
	Lower Senonian ..	Anderson, 33, p. 62.
Japan ..	Cenomanian ?	Yokoyama, 17, p. 170.
	Middle Cretaceous ..	Jimbo, 22, p. 11.
	Diff. Upper Cretaceous divisions	Yabe, 37, p. 5.
	Senonian	Bohm, in Yabe, 37, p. 4.
India—		
Aryalur and Valudayur	Upper Senonian	Kossmat, 28, p. 102.
Trichinopoly ..	Lower Senonian – Upper Turonian	Kossmat, 28, p. 102.
Utatur ..	Cenomanian – Lower Turonian ..	Kossmat, 28, p. 102.

In the general account in his *Geology*, however, Haug classes all those strata that contain the important fossils *Gaudryceras kayei* and *Pseudophyllites indra* in the Maestrictian formation. These strata are in general those that have been classed as Senonian or Santonian or Maestrictian by various authors. This point at least is apparent: All those strata that contain the two fossils named above are in all probability of the same age; and, since those authorities that are familiar with the species consider that they are closely related to *Gaudryceras planorbiforme* and *Gaudryceras colloti*, it becomes equally certain that this formation is very high in the Cretaceous succession, perhaps even in the Maestrictian. Included in these are the Aryalur, Valudayur, Nanaimo, Lower Chico, Quiriquina, Seymour Island, New Zealand, and Pondoland Upper Cretaceous formations. This has naturally led to wide generalizations, but it is perhaps right to call attention to the present state of our knowledge in regard to the distribution of such animals as ammonites. Information is, of course, meagre and indefinite, as we know nothing of the larval period, the swimming-powers of the animals, or their requirements as regards food or temperature. It appears, however, to be certain that *Baculites* and *Ptychoceras* were mud-borers in shallow water, and in this case, unless the larval period was long, they must have required a continuous shore-line with considerable areas of sheltered water in order to have become so widely distributed. *Diplomoceras*, also, must have had the most limited power of movement on the sea-floor. Species of other genera, such as *Pachydiscus*, perhaps had habits not very different from those of the present *Nautilus*, and, given suitable food and temperature-conditions, may have wandered rapidly along a variety of coasts.

There appears to be a general belief that the lytoceratids, in part at least, were stenothermal. Thus Spath speaks of the stenothermal genera *Phylloceras* and *Lytoceras* (53, p. 53). He also says that the Pondoland and Zululand faunas are connected by the presence in both of *Pseudoschloenbachia*—probably an active swimmer—and of benthonic crawlers and mud-boring *Baculites*, the stenothermal Lytoceratidae being dependent upon deeper water or warmer currents. The oxycone developments of the Upper Senonian, that might have been thought to be active swimmers, are often curiously restricted, and, like other marine organisms, may have a limited horizontal distribution. He notes, however, that Buckman differs, and thinks that it is wrong to generalize from our knowledge of the habits of Recent forms in regard to extinct groups.

Haug states on this subject, "La présence du genre *Phylloceras* et les Lytoceratidae au Japon, dans la Colombie Britannique, en Californie, au Chile, en Patagonie, et dans la Terre de Graham montre avec evidence que l'on n'est pas dans tous ces pays en présence de formations littorales mais qu'il s'agit de formations bathyales, déposées dans un géosynclinal étroit ou s'accumulaient de grandes épaisseurs de dépôt" (Haug, *Traité de Géologie*, p. 1349). He therefore includes much of the area of New Zealand in his "géosynclinal circumpacifique" (p. 1359).

If *Baculites* and *Ptychoceras* were mud-borers and *Diplomoceras* was a benthonic crawler, it is clear that in Upper Cretaceous times the coast-line round the Pacific was nearly continuous, if we are justified in assuming that these genera had a comparatively brief larval period. Since it has already been recorded that species of *Baculites* showing an Upper Cretaceous character occur in India, Pondoland, Chile, California, British Columbia, New Zealand, and New Caledonia, it is unnecessary to imagine that great swimming-powers were possessed by *Phylloceras* or the Lytoceratidae in order to account for the presence of species of these genera in the New Zealand fauna of that period.

The same conclusion is arrived at when the nature of the strata and the fossils embedded in them are considered. The strata certainly give evidence of deposition near a coast-line, for they are often sandy, and sometimes even pebbly and conglomeratic. Fragments of wood and leaves of several species of plants are not uncommon in most of the localities. Such fossils are, of course, most frequently preserved in strata that have been deposited in sheltered waters into which some rivers flow—certainly not in those deposited on an open coast-line nor on the floor of a geosynclinal area. As *Phylloceras* and species of Lytoceratidae are found in association with them, there is no reason to suppose that the presence of species of those groups is, in this case at least, any evidence of the existence of bathyal conditions in the New Zealand area.

The occurrence of identical or very similar species of *Gaudryceras* and *Phylloceras* in countries that now have such different climatic conditions as India, British Columbia, Chile, Patagonia, Seymour Island, and New Zealand, as well as Algeria and western Europe, appears at first sight to support the idea that these genera were stenothermal. However, it is found that closely related species of Puzosids, *Pachydiscus*, *Baculites*, *Madrasites*, &c., have an almost equally wide occurrence, and this term based on such an occurrence would be as applicable to them. It seems perhaps more reasonable to suppose that in Upper Cretaceous times the ammonites as a family were stenothermal, or that climatic zones were far less defined and extreme, and that temperature conditions over the world were far more uniform.

It may be positively stated that none of the formations in which Cretaceous fossils have yet been obtained in New Zealand give any evidence that they have been deposited in any deep synclinorium—even though the formation that in so many localities rests on the fossiliferous rocks of Cretaceous age is a greensand, succeeded by a forminiferal (mainly Globigerina) limestone sometimes siliceous and containing diatoms and radiolaria that may be of deep-water origin. Reasons have been given elsewhere, however, which seem to prove that this limestone is of Eocene age. It is a striking fact that similar material of wide occurrence in New Caledonia has lately been shown to be of Eocene age by A. Heim and A. Jeannet (*Bull. Geol. Soc. Geol. de France*, 1922, pp. 246–53).

It is noticeable that, with one or two exceptions, such as *Baculites chicoensis* in California and *B. rectus* in New Zealand, there is no evidence of a closer relationship of the New Zealand species of ammonites with those of distant lands than with those of nearer countries. In other words, it appears that the New Zealand species are more closely related to those that have been described from countries close to New Zealand than to those more distant, though exception must always be made of Patagonia. This general relation seems to indicate that the circum-Pacific coast-line was much the same in its position in Upper Cretaceous times as it is at the present day. In making this statement, however, it must be borne in mind that the Seymour Island and Chilian coast-lines were certainly not separated from New Zealand by such wide oceanic stretches as now. It is thought by Wilckens that there was a connection between these lands, either continuous or slightly interrupted, a good deal to the north of the present coast-line of the Antarctic Continent. So far as the ammonites of these three countries are concerned, it is almost certain that, though the species found in them are closely similar to those found in India, they are still more closely related to one another. The faunas differ from those of India in the absence of

species of such general and important genera as *Schloenbachia*, *Scaphites* (one species of *Scaphites* in Quiriquina, Chile), *Placenticeras*, &c., as well as in having such an unusual development of *Madrasites*, *Jacobites*, and *Gunnarites*.

As to the westward development of New Zealand in Upper Cretaceous times, we have at present no information. Australia seems to have no marine sediments of that age, and it was presumably above the sea-level at that time. Though this, too, was probably the case with the country on the west coast of the South Island of New Zealand, there appears to be no reason to believe that the basin of the Tasman Sea was then a land area, as has been lately suggested by Benson.

The ammonite fauna of Pondoland has been shown by Spath to have some distinct Indo-Pacific characteristics, as well as others of a distinctly Atlantic nature, in the presence of *Schloenbachia*, *Mortoniceras*, *Sphenodiscus*, and *Lenticeras*. The absence of these important genera in the faunas of Seymour Island and New Zealand seems to me to indicate that South Africa derived its Indo-Pacific elements directly from India along the coast of the western Indian Ocean, and that there was no association with the countries at the south of the Pacific Ocean.

It appears that the New Zealand ammonite fauna of Upper Cretaceous age is of such a nature that it indicates that the general position of the Pacific coast-line was much the same as at the present time. New Zealand was, however, more continuously united with Seymour Island and with India, though we do not at present possess enough information to show us exactly where this coastal connection extended.

STRATIGRAPHICAL FEATURES OF THE BATLEY SERIES.

The stratification of the Upper Cretaceous rocks of North Auckland is extremely difficult, if not impossible, to unravel with the amount of information at present at my disposal. At Batley there is practically no outcrop of the rock that has not suffered from superficial slipping. The same is true of the occurrence at Whangaroa; and at both of these places the small extent of the fossiliferous beach shows that the actual exposure of the Cretaceous sediments is small. At Bull's Point the stratification is almost vertical, and the thickness of the formation exposed is perhaps 300 ft. Here again, however, surface slipping and soil covering allow very little of the stratification to be seen. In all three localities no fossils have been found actually *in situ* in the strata. In nearly all cases they have been extracted from concretionary boulders, often of large size, lying on the foreshore. In a few cases only they have been extracted from the boulders by natural agencies, and were lying in the small rock-fragments on the beach.

It has already been stated that much of the fossiliferous rock is sandy or even pebbly, and it is therefore unlikely that the total thickness that is exposed represents much lapse of time. It is not reasonable to suppose that the interval from the Cenomanian to the Maestrictian should be represented by such a small thickness of sediments, which appear to have been deposited rather quickly. It was, of course, hoped and expected that definite species of ammonites would be found to be restricted to certain stratified divisions, and thus make it possible to define exact zones in the stratigraphical sequence. However, as the work proceeded and the collection became more extensive, it was found that no species of ammonites could be regarded as restricted in their occurrence to any particular portion of the

The question then arose as to whether this apparent mixture of zones could be due to the transport of material along the beach by wave-action. Full consideration of the conditions that actually exist, however, show that wave-transport must be small. If, for instance, the locality of Bull's Point be taken—for in this place the conditions would favour wave-transport more than elsewhere—the following facts must be noted :—

By far the greater number of the specimens were found on the side of the exposure extending west to east for about 100 metres on the north side of Bull's Point. At almost the same spot on the beach were found the following species: *Acanthoceras ultimum, Baculites rectus, Gaudryceras subsacya, Gaudryceras particostatum, Gunnarites inflatus, Tainuia aucklandica, Gaudryceras propemite, Maorites tenuicostatus, Phylloceras radiatum, Phylloceras forbesianum, Puzosia angusta, Parapachydiscus rogeri, Nowakites denticulatus, Zelandites murdochi, Pseudophyllites indra, Tetragonites epigonus, Tetragonites latus, Ptychoceras zelandicum.*

Several of these species appear to have distinct affinities with species from the Indian Utatur formation, which is, of course, definitely correlated with the Cenomanian. In this respect the following are most important: *Tainuia aucklandica, Acanthoceras ultimum, Phylloceras radiatum, Puzosia angusta, Gaudryceras subsacya.* Of these the species of *Acanthoceras* is particularly noticeable; for in the Indian ammonite fauna, which has 167 species, there are twenty-four of *Acanthoceras*, all of which were found in the Utatur series. It is obvious, therefore, that amoug the specimens found on the northern side of Bull's Point there is an important Utatur element, and it is certain that if any association of the species named had been found alone it would have been necessary to assign the formation to the Upper Cenomanian age. Associated with these species, however, as is shown in the list given above, there is a very distinct element of the highest ammonite horizon, for Haug has taken the species *Pseudophyllites indra* and *Gaudryceras kayei* (of the latter of which *Vertebrites murdochi* is merely a local representative) as typical of the Maestrictian in all those countries from which they have been recorded. In addition, *Diplomoceras wakanene, Ptychoceras zelandicum*, and *Baculites rectus* are indicative of a high horizon. The species of *Gunnarites, Madrasites*, and *Jacobites* also belong to an horizon distinctly higher than the Utatur. Thus on the north side of Bull's Point alone species are found that, judging by the Indian succession, would indicate that a great lapse of time is represented by the strata in a very small thickness of rock.

It must be added that a similar association of species has been found in each of the main collecting localities—viz., Bull's Point, Batley, and Whangaroa—though, since the collections made at both of the last two localities are much smaller than that made at the other, the variety of types that has been found is distinctly less. At Batley *Pseudophyllites indra, Vertebrites murdochi, Gunnarites inflatus, Maorites tenuicostatus, Baculites rectus, Tetragonites epigonus, Tetragonites latus, Ptychoceras zelandicum, Phylloceras forbesianum*, and *Gaudryceras subsacya* are relatively common. All of these are found at Bull's Point, though *Zelandites murdochi* was represented by one specimen only. At Whangaroa *Vertebrites murdochi* and *Ptychoceras zelandicum* are far more common than elsewhere, and perhaps *Hauericeras ngapuhi* also. On the other hand, *Pseudophyllites indra* is less common, as is *Baculites rectus*. *Phylloceras forbesianum* occurs, as well as *Maorites tenuicostatus*. It is thus clear that a similar association of ammonites occurs in each of the localities. The same is true also of the lamellibranchs and gasteropods, though it has not yet been found possible

to study them fully. Lastly, a species of *Araucarites* has been found quite commonly at each of the localities, represented by fragments of wood as well as leaves.

GEOLOGICAL AGE OF THE BATLEY SERIES.

It is proposed to call this the Batley series, after the locality where these northern New Zealand ammonites were first found. The similarity of the faunas shows that the same horizon or horizons are represented in each of the localities, and it is extremely unlikely that in such a small outcrop as that which is found at Batley and at Whangaroa there should be the same association of higher and lower strata as at Bull's Point, where the outcrop is a good deal larger. It therefore appears to be probable that either the association of species is different from any that has been found in India, or else this New Zealand horizon is intermediate in age between the Utatur and Aryalur horizons of India, but different from the Trichinopoly horizon. Any suggestion of correlation with the Trichinopoly horizon appears to be discounted by the occurrence of such forms as *Pseudophyllites indra*, *Vertebrites murdochi*, and *Diplomoceras ngapuhi*, all of which—or, rather, their local representatives – are restricted to the highest of the Indian ammonite horizons.

If it is agreed that all of these fossils are derived from a small range of horizons, we encounter a great deal of difficulty in correlating the New Zealand formation with equivalents elsewhere. It is necessary to take the Indian series as a guide. The table given on page 194 shows of the fifty-three Aryalur and Valudayur species there are eighteen representatives in New Zealand—that is, a percentage of 34; of the Trichinopoly fauna of twenty-six species there are four representatives, a percentage of 15·5; while of the large Utatur fauna of eighty-nine species there are only eleven representatives, a percentage of only 12·5. It is, then, clear that as regards the Indian ammonites the greatest affinity of this northern New Zealand Cretaceous fauna is with the Aryalur.

The same result may be arrived at in a different manner. If it is admitted that one horizon alone is represented, it is clear that it must contain either Utatur survivals or Aryalur antecedents. Even granting that the isolation of New Zealand was not nearly so extreme in the Upper Cretaceous times as now, it still seems that the former alternative is more probable than the latter.

It is therefore concluded that the Upper Cretaceous rocks of New Zealand are the equivalent of the Aryalur and Valudayur of India. All authorities are agreed in correlating this with a very high horizon in the Cretaceous of Europe. Kossmat takes the Upper Senonian: Spath for probably equivalent formations in Pondoland prefers the Upper Campanian plus Maestrictian, though van Hoepen regards these beds as Santonian. The Upper Senonian, however, is accepted by Kilian and Reboul, and generally by all of those who have described any series of Upper Cretaceous ammonites in the Indian Pacific region. On the other hand, Haug has adopted the Maestrictian equivalent for the Aryalur, and has correlated most of the circum-Pacific ammonite faunas with it. He appears to take as the criterion for this age the occurrence of the species *Pseudophyllites indra* and *Gaudryceras kayei*. According to this criterion, the Kaipara and Whangaroa ammonite fauna should be placed in the Maestrictian. My own opinion is that this is rather too high an horizon, and I prefer to take the Upper Santonian or the Lower Campanian as the more probable European equivalent.

Comparison with other Cretaceous Circum-Pacific Districts.

India.

As a basis for comparison, Kossmat's classification of the Indian formations is taken, and is quoted below. It will be noticed that there are 158 species in the Indian fauna, while there are only fifty-three in New Zealand.

		Trichinopoly.	Pondicherry.
Danian ..	..	c. Ninnyur.	c. *Nerinaea* beds.
Upper Senonian	Aryalur Group, 53 spp.	b. Kulmodu.	b. *Trigonoarca* beds.
		a. Otacod, Aryalur, Karapady.	a. *Anisoceras* beds =Valudayur (Blan.)
Lower Senonian	..	b. Upper Trichinopoly.	
Turonian ..	Trich. Group, 26 spp.	a. Lower Trichinopoly.	
Cenomanian	Utatur Group, 89 spp.	c. *Cunum* beds.	
		b. *Acanthoceras* beds.	
		a. Muraviatur, Odium, Utatur.	

Table showing the Generic Arrangement of Species in India and New Zealand.

	Tetragonites.	*Pseudophyllites.*	*Turrilites.*	*Hamites (Diplomoceras, &c.)*	*Baculites.*	*Neoptychites.*	*Placenticeras.*	*Sphenodiscus.*	*Forbesiceras.*	*Schloenbachia.*	*Sch. subgenera.*	*Stoliczkaia.*	*Acanthoceras.*	*Olcostephanus.*	*Scaphites.*	*Holcodiscus.*	*Brahmaites.*	*Pachydiscus.*	*Desmoceras.*	*Puzosia.*	*Hauericeras.*
Aryalur .	1	1	0	9	2	0	0	1	0	0	1	0	0	0	2	8	2	11	3	0	2
Trichinopoly	1	0	1	0	1	0	1	0	0	0	2	0	0	0	4	7	0	5	1	2	0
Utatur .	2	0	6	9	4	2	1	0	2	10	0	4	28	2	3	3	0	1	3	8	0
New Zealand	4	2	1	3	1	0	0	0	0	0	0	0	1	0	0	12	1	2	1	2	1

In this table *Hamites* includes *Diplomoceras*, *Ptychoceras*, and *Oxybeloceras*; while *Holcodiscus* ncludes *Madrasites*, *Gunnarites*, *Jacobites*, and *Maorites*, the last for comparative purposes only, without any suggestion as to affinities.

This table shows that the species which have been found in New Zealand belong in general to those genera which in India have a considerable range in time, and actually, with two exceptions, are represented in the formation which is correlated with the Upper Senonian in Europe. The exceptions are found in *Pseudophyllites*, *Turrilites*, *Puzosia*, and *Acanthoceras*. The only species of *Turrilites* that has been found in New Zealand came from the Clarence Valley, in the South Island. The two species of *Puzosia* are perhaps survivals, and this is more remarkable in regard to *Acanthoceras ultimum*, which is closely related to the well-known *Acanthoceras rotomagense*.

It is noticeable that twenty-eight species of this genus have been found in the Utatur formation of India. *Turrilites* also is represented by several species in India. The third of these genera—*Puzosia*—has species in the Senonian of Pondoland and Chile, the Lower Chico of California, and the Urakawa of Japan.

The species that it is considered do not belong to previously established genera are included in the following new genera: *Maorites*, probably a development of *Dalmasiceras* or of *Sonneratia*, a Hoplitid genus, and

probably related to some species that have been placed in *Puzosia*, a Desmoceratid genus; *Tainuia*, related to *Acanthoceras vicinale;* and *Neomadrasites*, derived from *Madrasites;* also *Vertebrites* and *Zelandites*, related to *Gaudryceras*. In the opinion of the writer these genera indicate a younger rather than an older horizon.

The outstanding features of this ammonite fauna when compared with that of India are most notably the complete absence of *Schloenbachia* and *Scaphites*. Another noticeable feature is the abundance of *Gunnarites* and *Jacobites*, both of which genera are included under *Holcodiscus* in the preceding table, which is based on the study of the Indian ammonites by Kossmat. It is also apparent that the genera *Phylloceras* and *Gaudryceras* are well represented. If the three species of *Maorites* are considered as closely related to the genus *Puzosia* it is clear that it has an unusual representation.

So far as a general statement can be made of the generic features, one is justified in saying that the fauna follows very closely on the main features of the Indian fauna. When the species are compared it is found that there is a considerable number of the Indian species that are extremely close to some in New Zealand. The following species appear to be almost, if not quite, identical: *Phylloceras nera*, *Phylloceras forbesianum*, *Vertebrites murdochi* cf. *Gaudryceras kayei*, *Gaudryceras politissimum*, *Gaudryceras subsacya*, *Pseudophyllites indra*, *Tetragonites epigonum*, *Haueriteras ngapuhi* cf. *gardeni*, *Gunnarites antarcticum* cf. *Holcodiscus kalika*, *Brahmaites rotundum*, *Ptychoceras zelandicum*, and *Diplomoceras wakanene*. This great similarity seems to indicate either that a coast-line was almost continuous from India to New Zealand, or that the species had remarkable powers of dispersion. In connection with this it is well to remember that there seems to be a general agreement that the Phylloceratidae and Lytoceratidae had such free-swimming powers that they were distributed by ocean currents. It is, however, almost impossible that such relatively fixed forms as *Baculites* and *Ptychoceras* could have had such means of distribution.

Japan.

This fauna appears to be much less closely related to the ammonite fauna of Japan than to that of India. As in New Zealand, no species of *Schloenbachia* have as yet been recorded from Japan. *Madrasites*, however, is not well represented, but species of *Jacobites*, *Gunnarites*, and *Baculites* have not yet been discovered. On the other hand, the species of *Phylloceras*, *Gaudryceras*, and *Tetragonites* show a good deal of resemblance to New Zealand forms, though it may be said that the species of the two last genera, having little ornamentation, have not so much opportunity of displaying striking differences.

The numerous Japanese species of *Desmoceras* constitute a striking feature, and it seems as though there are no forms in Japan that show analogy with the species of *Maorites*. The genera *Placenticeras*, *Olcostephanus*, *Crioceras*, and *Scaphites*, which are absent from the New Zealand fauna, have been found in Japan, as well as a great variety of *Turrilites*, which, however, come from the lower horizons. The widely distributed species *Pseudophyllites indra* and *Gaudryceras kayei* appear to be unrepresented in Japan, while the *Gaudryceras sacya* of Yokoyama and Jimbo is referred by Yabe to a new species, *G. tenuiliratum*.

California.

The Chico formation is well known to include at least one horizon which is universally admitted to be of Senonian age. Anderson's list of the Upper Chico (Lower Senonian) fauna on page 27 includes twelve species of ammonites only. Of these, eight belong to the genera *Ancyloceras*, *Helicoceras*, *Schloenbachia*, and *Hoplites*, none of which genera are represented in the New Zealand fauna as at present known. Of the remainder, *Baculites chicoensis* is the only species which shows close relationship to the New Zealand forms. The small number of species does not allow a comparison of any great value to be made. The Lower Chico, however, which is of Turonian age, has a much larger and more representative fauna, and some forty-four species of ammonites are included in it. Among these are twelve species of *Schloenbachia* and six of *Scaphites*, which again are genera unknown at present in New Zealand. Of five species only can it be said that there is a definite relationship.

At Mount Diablo there is a fossil-bearing formation, the exact age of which, and relation to the other formations, has not yet been satisfactorily settled. This horizon is of special interest, for it contains *Gaudryceras kayei* and *Acanthoceras turneri*, both of which are rather close to New Zealand species of ammonites.

From these statements it would seem that the Californian fauna had certain affinities with the Atlantic fauna that were not shared by New Zealand. *Schloenbachia*, though so common in Europe and Africa, and extending to India, is nevertheless absent from the Upper Senonian fauna of many circum-Pacific countries. *Mortoniceras* also is represented in California, though absent from all other Indo-Pacific faunas. (This genus has lately been recorded from Japan.)

British Columbia.

In this country Whiteaves has described two different series of Cretaceous ammonites. The lower of these two formations was found in the Queen Charlotte Islands, and the fossils contained in them are considered by Haug to be indicative of the Albian or the base of the Cenomanian. However, *Gaudryceras sacya*, *Tetragonites timotheanus*, and perhaps *Hoplites beudanti*, show some affinities with members of the New Zealand ammonites. On the other hand, the presence of the genera *Schloenbachia*, *Sphenodiscus*, *Olcostephanus*, and *Ancyloceras* establish a complete difference from the New Zealand fauna, as well as from that of Seymour Island and of Quiriquina, and perhaps also from that of South Patagonia.

The Nanaimo fauna, however, which is considered by Haug to be of Maestrichtian age, and by other authorities to be of Upper Cretaceous age, shows many points of resemblance to the present fauna. The presence of such species as *Pseudophyllites indra*, *Gaudryceras kayei*, *Baculites chicoensis*, *Phylloceras velledae*, and *Hauericeras gardeni* at once establishes a relationship that must be regarded as a close one.

Patagonia.

Paulcke has identified twenty species from South Patagonia. These display a considerable difference from those of Seymour Island, Chile, New Zealand, and Japan, especially in the presence of a large series of *Hoplites plasticus* sp. This series Paulcke himself and Haug compare with North European species, and it thus appears that South Patagonia may have had an Atlantic connection that did not extend to the other

countries mentioned. The other Patagonian genera are all represented in New Zealand and in other circum-Pacific countries. *Pachydiscus* and *Baculites* have four and three species respectively, but *Gunnarites* and *Jacobites*, which are common in Seymour Island and New Zealand, have no Patagonian species. Again, there are no species of *Puzosia*, *Hauericeras*, or *Desmoceras;* and it is noticeable that *Vertebrites murdochi* has no representative species, though it has such a wide Indo-Pacific occurrence.

The species of *Hoplites* give this fauna a most distinctive character when compared with the other South Pacific ammonite faunas. In other respects, however, all the elements of the fauna might well be found amongst those species that have been found in the north of Auckland.

Chile.

The only locality from which ammonites have been recorded is the island of Quiriquina, in the Bay of Concepcion. Nine species only have been recorded. All the genera, with the exception of *Scaphites*, are represented in New Zealand. The species that have been recorded show a considerable resemblance to New Zealand species. Though this is a small collection, it seems to show a closer affinity with New Zealand species than that of any other country except Seymour Island.

Seymour Island.

The New Zealand ammonites show rather a close relationship to those described by Kilian and Reboul from Seymour Island, a point to which Kilian has already drawn attention. It is in the genera *Madrasites*, *Gunnarites*, *Jacobites*, and perhaps *Maorites*, that this is most markedly shown, for these genera have a fuller representation in both countries than in any other. The species of *Phylloceras*, *Gaudryceras*, and *Tetragonites* are also rather similar, but perhaps no more so than in the ammonite faunas of the other circum-Pacific countries where Upper Cretaceous ammonites have been described. On the other hand, the absence of *Baculites* and *Ptcychoceras*, especially the former, is rather surprising. On the whole, as previously remarked and as shown in the tables on previous pages, the Seymour Island fauna is more closely related to New Zealand than that of any other country.

FOSSILS FOUND WITH THE AMMONITES.

Remains of a large number of organisms have been found in association with the ammonites.

The plant-remains are described by Mr. W. N. Edwards in the present volume (pages 121–128).

An echinoid was sent to Dr. Bather; he forwarded it to Professor Hawkins, who was good enough to examine it, and he remarks that it is probably a true *Hemiaster*.

Dr. Smith Woodward was good enough to examine the fish-scales, and detected some that were characteristic of *Cladocyclus*, a fish of the Cretaceous family Ichthyodectidae.

Two species of brachiopods were sent to Dr. J. A. Thomson, who forwarded them to England, but no report has yet been received.

There are about twelve species of gasteropods, which include a form close to *Amberleya spinigera* Wilckens, from Seymour Island.

The lamellibranchs include a species of *Thyasira* close to *T. townsendi* Wilckins, from Seymour Island. It is hoped to classify the species of gasteropods and lamellibranchs next year.

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A New Species of *Osmundites* from Kawhia, New Zealand.

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hutton and Hector Medallist, N.Z. Institute.

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Plates 48–54.

WELL-PRESERVED fern-foliage has long been known to occur in the Jurassic rocks of New Zealand. The best-known localities are Waikawa, in the extreme south-east of the South Island; Mataura, about forty miles to the north of Waikawa; and a place a short distance south of the Waikato Heads, in the North Island. The localities in the two Islands are separated by about six hundred miles. This foliage has been mentioned under a considerable variety of names. Unger (1864) called it *Polypodium Hochstetteri*. Hector (1886, p. 66, fig. 3) referred to foliage of a similar nature as *Pecopteris grandis*. Marshall (1912) has referred to the ordinary kind of foliage under the name *Alethopteris*. Arber (1913), however, has pointed out that this common type of foliage is properly classed in the well-known genus *Clodophlebis*, and he includes it provisionally under the name *C. australis* Morr. Though foliage has often been collected, associated stems have seldom been found. Dunlop and Gibbs collected two near Gore in 1905, and these have been described by Kidston and Gwynne-Vaughan (1907) under the names *Osmundites Dunlopi* and *O. Gibbiana*.

No fern-stems have yet been described from the Jurassic rocks of the North Island. A well-preserved specimen was collected in 1902 at Motutara Point, on the north shore of Kawhia Point. It was taken from the centre of a large spherical concretion in a formation from which the following Mollusca have been collected: *Perisphinctes brownei* Marshall, *Perisphinctes* sp. Boehm, *Phylloceras kawhiae* Marshall, *Belemnites canaliculatus aucklandicus* Hauer. These fossils give a basis for estimating the geological age of the formation, and it is considered by Boehm (1911) to be

"Grenzschichten zwischen Jura und Kreide." New Zealand geologists place the beds in the Upper Jurassic.*

No fern-foliage has yet been found in these beds. The nearest point at which it has been found is at Hochstetter's locality, about thirty miles farther north. The species found there was *Cladophlebis australis* Morris, already mentioned, and also a species of *Sphenopteris*. On examination the fern-stem proved to be in an excellent state of preservation. It is generally similar to other described species of *Osmundites*, but the leaf-bases appear rather more numerous and smaller.

The specimen, originally much longer, in its present state is 6 cm. long by 12 cm. in cross-section. It consists of a stem covered by leaf-bases ten layers thick. The stele measures 18 mm. in diameter; the pith, 5 mm.; the xylem ring, 1 mm.; the inner cortex, 1½ mm.; and the outer cortex, 4 mm. in diameter. Each of these regions is quite circular, as the specimen has been altogether free from the effects of pressure. The diameter of the pith is much greater with reference to the width of the xylem ring than in *Todea (Leptopteris) superba* and *T. hymenophylloides*, but less so than in *Todea barbara*, from which, however, it differs in several important respects, especially in the continuity of the xylem ring. It is considered that the structure is sufficiently distinct to justify the creation of a new species.

Osmundites aucklandicus n. sp.

Description of the Stem.

(*a.*) *The Pith.*—This is somewhat imperfectly preserved and appears to have shrunk before fossilization. It consisted mainly of thin-walled parenchyma, but occasionally some of it is sclerenchymatous, though such strands are quite irregularly placed. No trace of xylem tracheids could be seen anywhere in the pith, and no internal phloem could be seen. In the cross-sections shown in the figures the structure is not well shown. Longitudinal sections are far more satisfactory, but none of these are figured.

(*b.*) *Xylem Ring.*—This consists of about forty to fifty strands of xylem, forming a most complete ring, and separated by extremly narrow bands of parenchyma often only one cell thick. The thin separating bands of parenchyma are always connected with the xylem sheath and are clearly continuous with it. In about one-third of the bands the parenchyma does not extend inwards to the pith. The xylem ring is ten or eleven elements wide, those near the periphery being of smaller diameter than those near the inner border of the ring. The xylem ring thus has about as many strands as that of *O. skidegatensis* and *O. Kolbei*, but

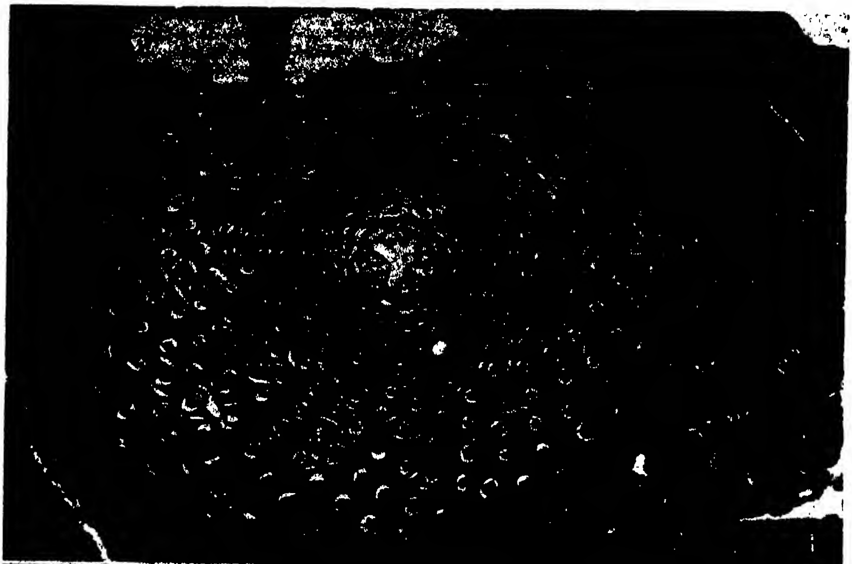
* In 1915 Dr. C. T. Trechmann took to England a collection of New Zealand Jurassic fossils, and subsequently wrote an important paper on the Jurassic rocks of New Zealand (*Q.J.G.S.*, vol. 79, pp. 246–312). Dr. Spath described and classified the ammonites in this collection, and reviewed the previous literature on the subject. The species of Mollusca from the Kawhia localities Te Puti and Motutara were reclassified as follows: The ammonites *Uhligites hectori* Spath, *Streblites motutaranus* Boehm, *Aulacosphinctoides brownei* Marshall, *A.* sp. indef., *A. marshalli* Spath, were considered to indicate a Tithonian age; *Belemnopsis* sp., Kimmeridgian; *Discina kawhiana* Boehm, Upper Jurassic. Two additional Mollusca, *Lima* aff. *gigantea* Sow. and *Belemnites canaliculatus aucklandicus* Hauer, were not regarded as indicating any special horizon.

they are much more numerous than in other species, excepting *O. Dunlopi*, which is described as having a continuous xylem ring. On the other hand, the thickness of the ring is less than in *O. skialegatensis* and *O. Kolbei*, but greater than in the other species. It is doubtful whether these characters in themselves are of any value for specific distinction. In longitudinal section the walls of the tracheids are clearly reticulately pitted as described by Kidston and Gywnne-Vaughan. In the larger vessels the pits are multiserial, but they are seldom in vertical rows. (cf. *Zalesskya gracilis* Kidston and Gwynne-Vaughan, pt. 2, pp. 221, 22.2). In transverse section the structure is rather peculiar, and more resembles that of *Zalesskya* than any described species of *Osmundites* or *Todea*. As seen in transverse section, an empty space extends along the centre of the cell-wall, but there is a thin black line which appears to extend along the whole length of this empty space. The empty space is most noticeable at the corners where three or more tracheids meet. At the angle there is an empty three-cornered space with a three- or four-rayed black star within it. In Plate 51, fig. 2, it is clearly seen that the ray of the star forks where the three-cornered space passes into the linear space between the adjacent cell-walls. In *Zalesskya* Kidston and Gwynne-Vaughan show no empty spaces, and in *Osmundites* and *Todea* the black line is not seen, while the empty three-cornered space at the angles is not present, and again the linear space between the adjacent cell-walls is interrupted where the buttresses between the vertical rows of pits are situated. It is thus evident that the structure of the xylem consists of tracheids almost separated from one another. Wherever the tissue is fractured the crevice runs along the centre of the tracheid walls. The present species, therefore, has a more continuous central black line than *Zalesskya*, and a more pronounced development of the vacant spaces in the tracheid wall than *Osmundites* and *Todea*.

(*c.*) *The Xylem Sheath.*—This is about three layers of cells thick. The cells are of relatively smaller diameter than the tracheids and have much thinner walls. The cells are elongated and pointed. As previously mentioned, the xylem sheath is always connected with the parenchyma that separates adjacent xylem bundles. In both longitudinal and transverse sections the structure of the xylem sheath and the separating parenchyma appears to be identical. Conspicuous differences distinguish this parenchyma from the short-celled tissue of the pith. It is therefore suggested that the parenchyma bands are derived from and are a part of the tissue of the xylem sheath, and not of the pith. The idea is supported by the apparently similar nature of the granular matter that fills the cells of both of them. That the parenchyma bands are derived from the xylem sheath has been proved by Gwynne-Vaughan (1911) in the case of *Osmunda regalis*.

(*d.*) *The Phloem.*—This forms a continuous layer of nearly uniform thickness outside the xylem sheath. It consists almost entirely of sieve-tubes, some of which have a diameter little inferior to that of the majority of the xylem tracheids. In longitudinal section the sieve-plate structure can be distinctly seen. The exterior layer of the phloem is composed of tangentially elongated cells, but they do not show very distinctly in any of my preparations.

(*e.*) *The Inner Cortex.*—This consists of thin-walled parenchymatous tissue, but, like the pith, it appears to have shrunk greatly before fossilization took place. There are two rows of leaf-traces in this inner cortex. Each of the rows has about twelve leaf-traces.



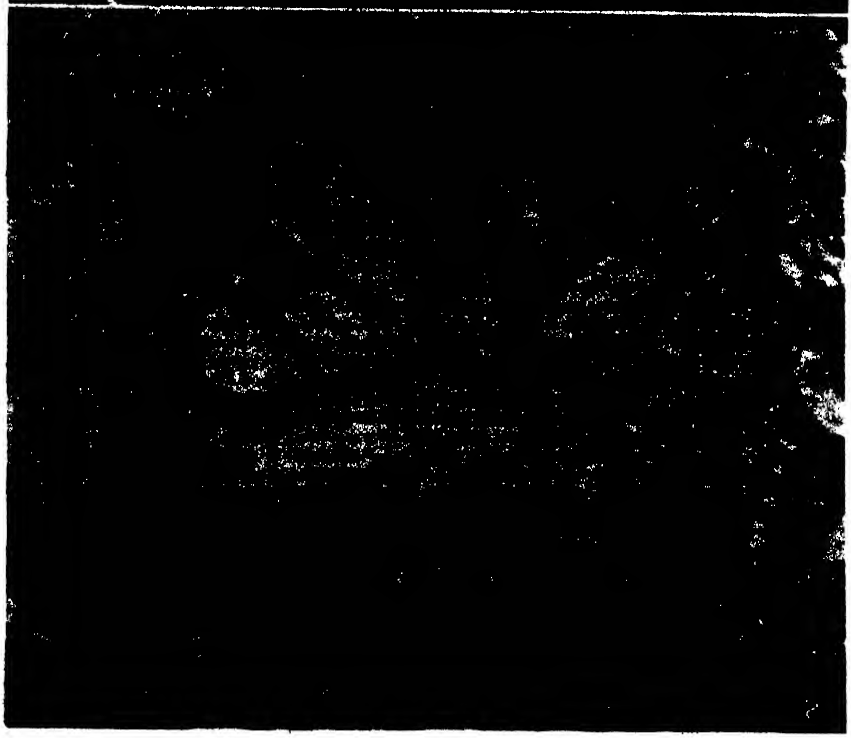


Fig. 1.—Transverse section of stem of *Osmundites aucklandicus*; × 2.
Fig. 2.—Transverse section showing pith, xylem ring, and part of inner cortex; × 15. *a*, protuberance on ring in preparation for formation of leaf-trace; *b*, leaf-trace just departing from xylem ring; *c*, leaf-trace further developed, showing one root; *d*, completely formed departing leaf-trace, showing two roots developing laterally. × 15.

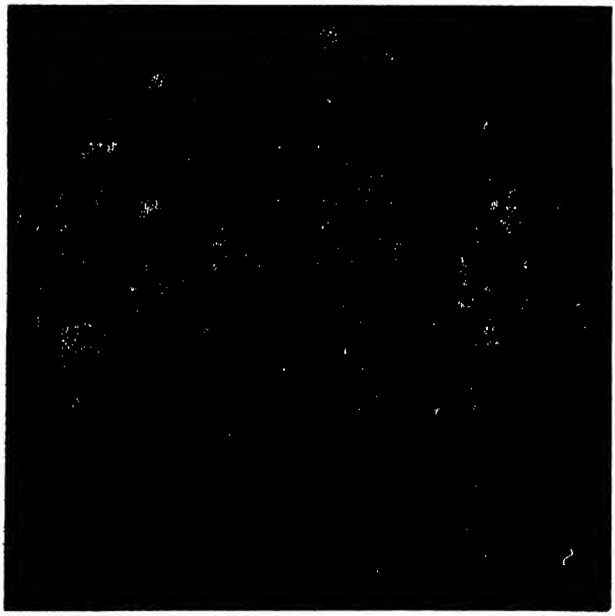
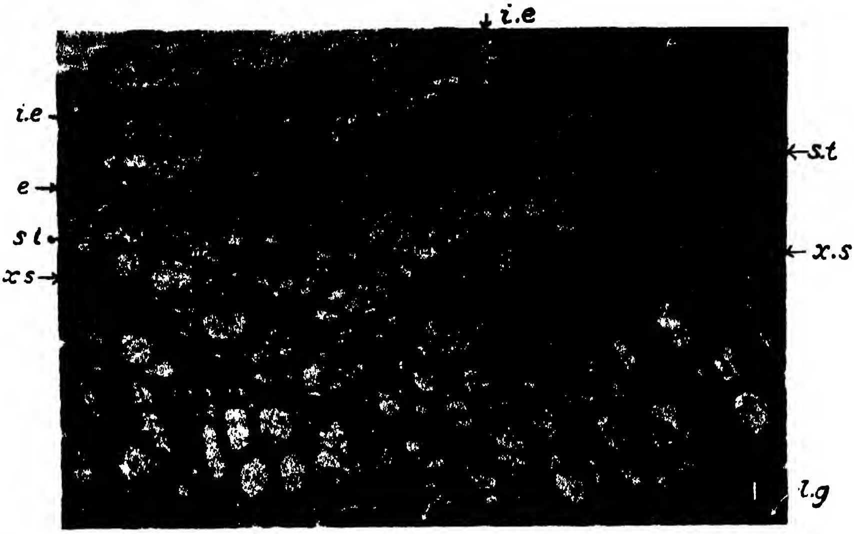


FIG. 1.—Transverse section of *Osmundites aucklandicus* showing portion of xylem ring and of inner and outer cortex with two roots; × 10. At *a* and *b* two leaf-traces departing without leaving any leaf-gap or band of parenchyma in the xylem.

FIG. 2.—Portion of outer part of xylem ring showing leaf-gap (*l.g.*), xylem sheath (*x.s.*), part of xylem ring (*x.*), sieve-tubes of phloem (*s.t.*), endodermis (*e.*), inner cortex (*i.c.*); × 100.



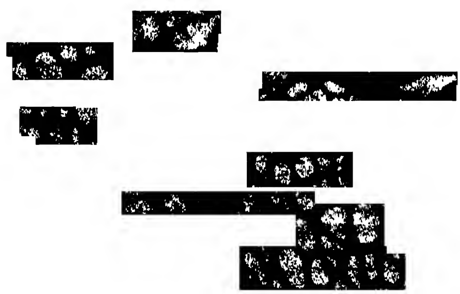
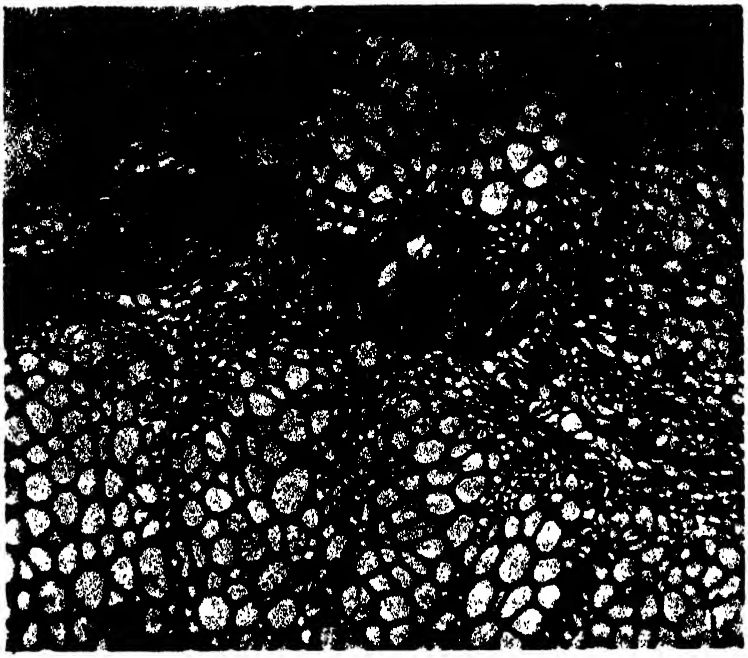


Fig. 1.—Portion of outer part of xylem ring showing leaf-gap (*l.g.*). Lettering as in Plate 49, fig. 2. × 80.

Fig. 2.—Leaf-trace about to depart from xylem ring; × 50. A small rock-fracture is seen to traverse the tissue along the middle line of the tracheid walls.



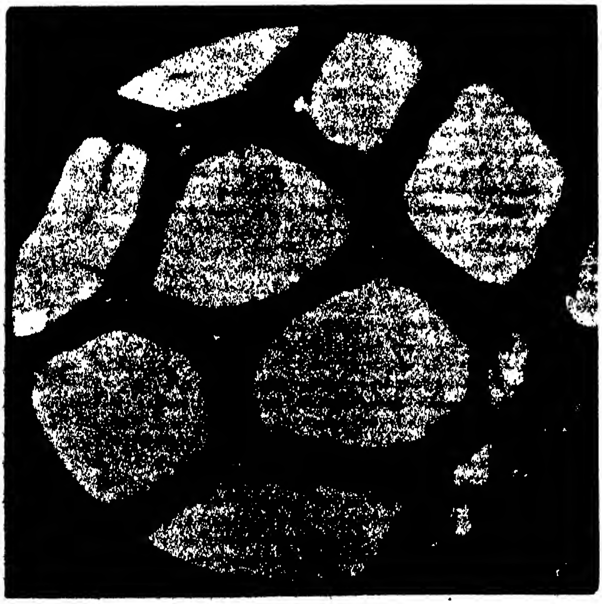
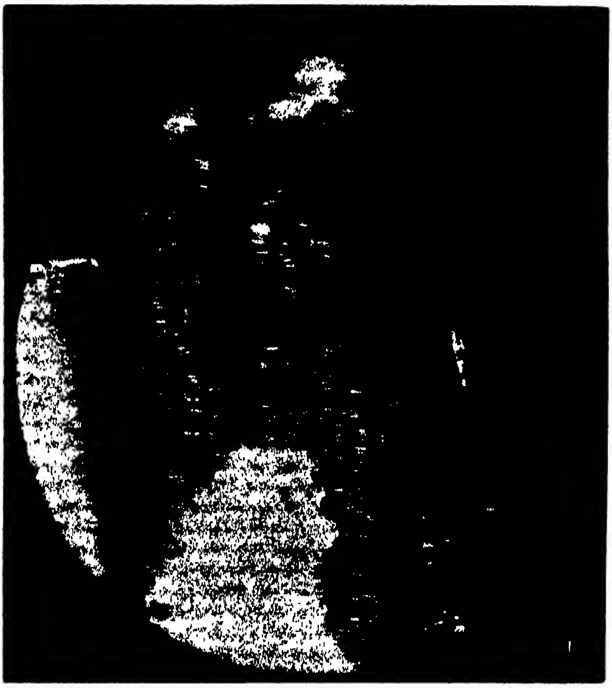


Fig. 1.—Leaf-trace just departed, showing well-developed leaf-gap and continuous xylem sheath. × 50.

Fig. 2.—Section of xylem tracheid showing empty spaces at corners with three radiating black lines; also in some instances black lines in centre of empty spaces between tracheid walls. × 300.



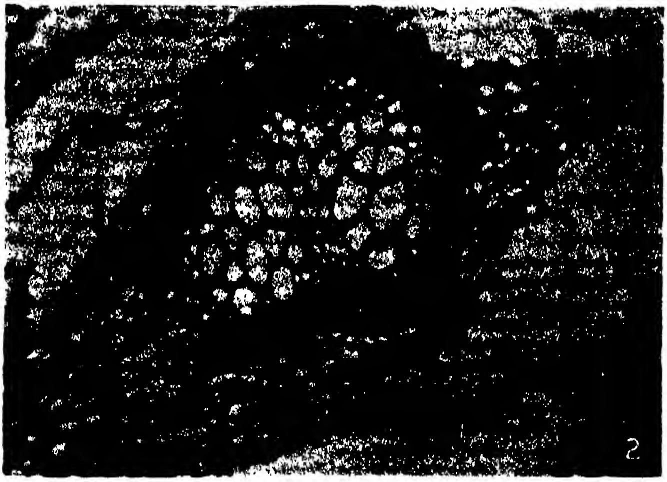


FIG. 1.—Longitudinal section of tracheids showing pitted walls; × 150.
FIG. 2.—Leaf-traces passing through inner cortex; × 50.

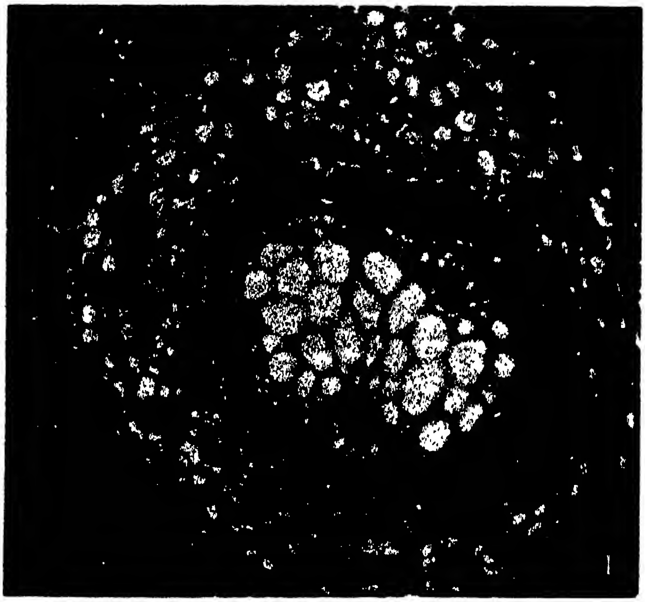


FIG. 1.—Leaf-trace passing through outer cortex; × 50.
FIG. 2.—Leaf-base with stipular wings showing the strands of sclerenchyma; × 15.

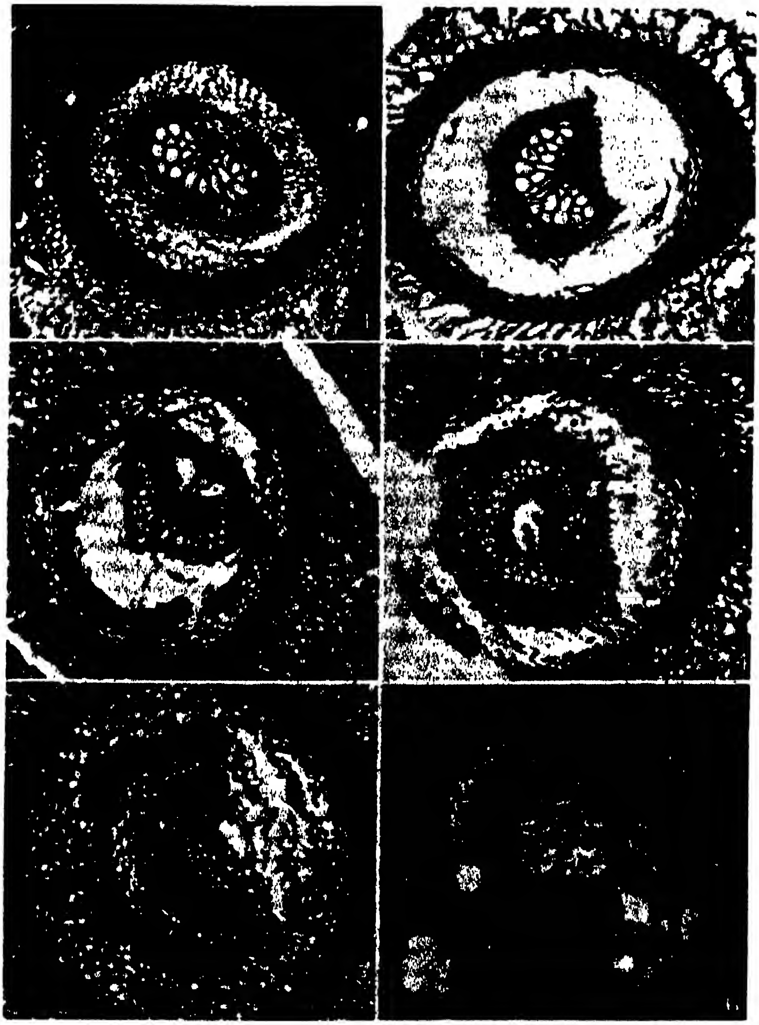


FIG. 1.—Leaf-trace departing from outer cortex; × 50.
FIG. 2.—Leaf-base with xylem assuming a horseshoe shape; × 50.
FIG. 3.—Leaf-base with xylem further developed; × 50.
FIG. 4.—Leaf-base showing the formation of sclerenchyma strand within the bend of the horseshoe; × 50.
FIG. 5.—Leaf-base with sclerenchyma more developed; × 50.
FIG. 6.—Final form of the leaf-base near the margin of the specimen; × 30.

(*f.*) *The Outer Cortex.*—There are four rows of leaf-traces in this region of the stem, each of which consists of about twelve leaf-traces. The tissue of the outer cortex consists of thick-walled sclerenchyma that is of a uniform nature throughout. The roots traverse this tissue as well as that of the inner cortex. The outer cortex appears to be much thicker than in other described species, though *O. Dunlopi* approaches it in this respect. The outer part of the specimen consists of closely adherent stipular leaf-bases. In these the parenchyma strands have a distribution which approaches most closely to that in *Todea superba*, though there are considerable differences. The leaf-traces are given off in a manner very similar to those of *Todea*. The pocket of xylem sheath starts just above the actual leaf-trace and gradually extends across the xylem ring, but does not always reach the pith. The protoxylem is at first almost mesarch in a few instances, but soon becomes exarch in all. The leaf-trace passes through the inner and outer cortex in the usual manner, and acquires a ring of each of these tissues during its passage. The form of the leaf-trace is reniform until it has passed through the outer cortex, and it then rapidly becomes horseshoe-shaped. In passing through the outer cortex the xylem of the leaf-trace becomes somewhat smaller, and the number of tracheids is reduced. This smaller number is retained until the horseshoe shape is well developed. At about the sixth ring of leaf-traces outside the outer cortex a small amount of sclerenchyma begins to appear within the bend of the horseshoe of xylem; this soon divides into two strands of sclerenchyma, and the leaf-base develops an appearance somewhat similar to that of *Todea barbara*.

This species of *Osmundites* appears to resemble *O. Kolbei* more closely than any other species that has been described. Its woody structure, however, appears to connect *Osmundites* with *Zalesskya*. Though a relatively early species, it has a complete wide pith without any tracheids; the xylem ring also is narrow with reference to the diameter of the pith. The breaks in the xylem ring are very numerous, a fact that is obviously related to the large number of leaf-bases. It is clearly seen that the parenchyma that breaks the xylem ring is derived from the xylem sheath.

The type and microscopic preparations are deposited in the botanical department, Otago University.

I am much indebted to Dr. Holloway for pointing out some inaccuracies in the proof.

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Geology of Cordy's Flat, Malvern Hills, Canterbury.

By G. Jobberns, M.A., B.Sc., Christchurch Training College.

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Contents.

1. Introduction.

This paper is a summary made from a thesis presented in 1920 for the M.A. degree of the New Zealand University. As a description of the Cordy's Flat area it follows to a considerable extent the published work of Haast, Hector, and Cox, all of whom were attracted to the locality in the early days by the discovery of brown coal. The area described is situated just beyond the Whitecliffs Railway-station, forty-two miles west of Christchurch, and forms a part of the Malvern Hills.

2. Physiography.

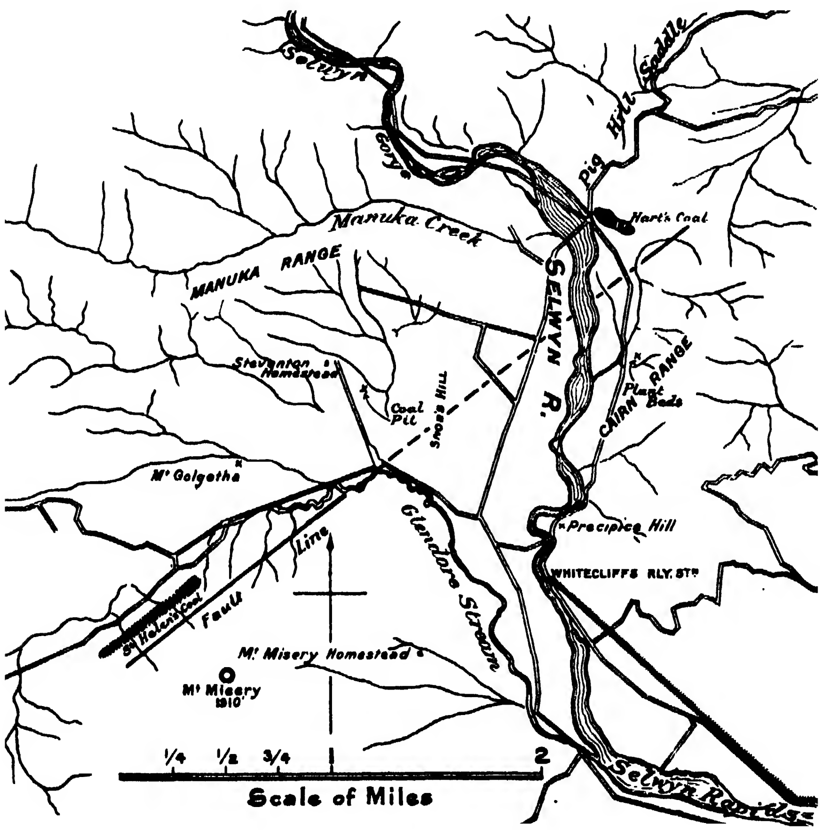
Cordy's Flat is a fairly large depression partly infilled by coarse alluvial gravels. Surrounded on all sides by older rocks, it contains isolated coal-bearing remnants of a former more widespread "Cretaceo-Tertiary" mantle (17, p. 345), which have in some places been completely removed and in others obscured by the thick alluvial deposits of the Selwyn River and its tributaries, Glendore and Manuka Creeks. The depression itself has been determined by a powerful dislocation, the Cordy's Flat fault, which runs across the flat in a north-east and south-west direction, and has a considerable downthrow to the north-west. This is No. 1 of the series of subparallel faults described in Professor Speight's recent paper on the Benmore coal area (19, map, p. 620). The higher ridge of the Flagpole Hill range has been deeply cut to form the narrow gorge through which the Selwyn debouches into the north-west corner of the flat. Park (15, p. 239) states that a branch of the Rakaia Glacier reached the Canterbury Plains via the Selwyn Valley, but in this area there seems to be no definite evidence of glacial action, and no need to invoke its agency for a satisfactory explanation of the surface features. Cordy's Flat may therefore best be described as an intermontane basin arising from the faulting which accompanied the elevation and folding of a pre-Pliocene peneplain.

3. Detailed Stratigraphy.

A. *Maitai Rocks.*

Rocks assigned to the Maitai series as defined by Cox (3, p. 24) form the greater part of the north-west boundary of Cordy's Flat from Mount Golgotha to the Pig Hill saddle, across which they probably continue beneath the recent accumulation of swampy alluvium, silt, and gravels until at the Cordy's Flat fault they butt against the Jurassic sandstones

of the Cairn Range. The Maitai rocks consist of greywackes and sandstones which in many places have been rendered slaty by the pressure of sharp folding. They are everywhere steeply inclined, and in the bed of the Selwyn about a quarter of a mile above the Springfield road-crossing they strike N. 40° W., with an easterly dip of 65°, while the same general direction of strike is to be found in the rocks to the south-west of the Manuka Range. The greywacke, as shown by thin sections of samples from various points, is of a very uniform type, containing a considerable amount of calcium carbonate. The rock seems everywhere considerably



MAP OF PART OF MALVERN HILLS DISTRICT.

altered, the sections showing abundant epidote, together with much kaolin, presumably produced by the weathering of potash feldspar. The evidence available does not assist in assigning a definite age to the greywackes, but their unconformable relationship to the Jurassic rocks of the Cairn Range is discussed in a subsequent section.

B. *Jurassic Rocks.*

Rocks of Jurassic age constitute the northern part of the Cairn Range from the neighbourhood of Precipice Hill to the Cretaceous outlier near Hart's coal-pit. They are again exposed on the north-western side of

Cordy's Flat, where they form Manuka Range, the series of ridges lying at the eastern base of Flagpole Hill. Erosion, followed by deposition of river-gravels in the intervening valley, has made impossible any definite statement of the exact stratigraphical relationship between the beds in the two areas, but they are lithologically similar, and in all probability are continuous under the gravels of the flat at no great depth.

Extensive surface slumping, due to the steepness of the slopes and the incoherent nature of the strata, the masking of the base by accumulated talus, and the thick mantle of vegetation, render the accurate observation of the structure of the Cairn Range difficult. In their brief references to this locality both Haast and Hector seem to have overlooked the structural importance of the Cordy's Flat fault, the scarp of which is preserved in the northern extremity of the range. Here the greensand strata of the "Cretaceo-Tertiary" outlier may be traced for some distance up a ravine-like gully, the course of which seems to have been determined by the infold of a local syncline. The south-easterly dip of the greensands is somewhat flattened until they disappear beneath an accumulation of talus material just below the sharply-defined shoulder of the fault-scarp. Immediately above this are extremely brecciated argillites and decomposed greywacke, with a thin coaly band showing distortion of dip, the whole resting against the slickensided surface of sandstones with plant-remains similar to those exposed a little farther south at the summit of the range. Though considerable movement has occurred here, it is evidently not in the plane of the major fault, which, some few yards farther down, is completely obscured by slip-debris.

The strata exposed here strike east and west, with a southerly dip; the fault runs north-east and south-west (magnetic), with downthrow to the north-west; while the sandstone bands of the southern side of the gully are inclined north-north-west. Thus the general structure here is characterized by synclinal folding with faulting.

From the summit of the ridge above the fault-scarp to the foot of the range below the plant-beds the downward succession of strata is as follows:—

(6.) (*a.*) Soft friable sandstone, or "freestone," light-coloured, composed of loosely-cemented quartz-grains with occasional irregular secretions of iron oxide.

(*b.*) Similar rock to above, but with a fine lamellar banding, due to deposition of reddish ferruginous material in alternating layers.

(5.) Bands of earthy and coaly shales varying in thickness from a few inches to several feet. These occur at more or less regular intervals, and interstratified with them are—

(4.) Fine-grained sandy conglomerates, passing down into thick beds of coarse incoherent conglomerates composed of rounded pebbles of greywacke and sandstone.

(3.) Massive bands of compact hard deep-brown sandstone which in many places has a thin platy horizontal parting as well as vertical jointing.

(2.) Dull-brownish earthy sandstones in relatively thin bands. containing plentiful fragmentary plant-remains in a remarkably good state of preservation.

(1.) Thin bands of a particularly hard compact sandstone, so calcareous as to show abundant white calcite on cross-fracturing.

The highest portion of this northern range is the denuded crest of an anticline, the beds observed dipping north-north-west at an angle of 10° to 15°. The numerous alternations of sandstones, conglomerates, and shales, with great variation in thickness, indicate long-continued oscillation of base-level.

Plant-beds.—The best exposure of the plant-bearing earthy sandstones occurs immediately below the point where the upturned edges of the conglomerates, sandstones, and shales of the northern part of the Cairn Range are exposed at its summit. The downward succession of strata here may be summarized as follows :—

(7.) Fossiliferous sandstone—a thin band containing very plentiful plant-remains.
(6.) Black earthy shales attaining a thickness of 25 ft., containing rapidly-alternating clayey streaks.
(5.) Hard calcareous sandstone—unfossiliferous thin band.
(4.) Black shales resembling (6)—10 ft.
(3.) Sandstone like (7), but plant-remains not abundant.
(2.) Coarse conglomerates—6 ft.
(1.) Sandstone. Plant-remains occur very sparingly.

Shales with interstratified sandstones and conglomerates continue to the foot of the range, but the richly fossiliferous bands are restricted to the upper horizon.

Below the plant-beds the face of the hill has been covered with slumped blocks from landslips. The presence of massive greywacke crags on the summit of the ridge behind an isolated farmhouse suggests that the central part of the Cairn Range consists of greywacke. The strike of the greywacke is approximately north and south (magnetic), and the beds are almost vertical. It appears, then, that the Jurassic rocks of the northern part of the Cairn Range form part of a large anticlinal fold over this greywacke core, with which they are sharply unconformable.

The Manuka Range, on the opposite (or western) side of the Selwyn, is so densely covered with stunted scrub that only one outcrop of the component rocks was found. A small landslip reveals the following ascending sequence of strata :—

(1.) Compact sandstone with plant-stems in position (in bed of small stream).
(2.) Much-weathered crumbly argillite.
(3.) Brown coaly shale in thin bands ; dip, N.W. 30°.
(4.) Argillite with ferruginous concretions.

Some distance above are the following :—

(5.) Fine sandy conglomerate.
(6.) Coarse incoherent sandstone and greywacke conglomerate.

Thin sections of pebbles from the conglomerate (bed 6) show them to be largely greywackes identical in character with the Maitai greywacke described above, and with the pebbles of the Cairn Range conglomerates. The conglomerate may be traced along the summit of the Manuka Range, its general strike being E. 10° N. At the northern extremity of the range the Maitai greywacke is found *in situ*, but no contact is exposed.

Unconformity between the Maitai Greywackes and the Cairn Range Beds.—The nature of the Cairn Range conglomerates demands the existence of the greywackes prior to the deposition of the Cairn Range beds. Haast overlooked this point, and, regarding the latter beds as inferior in position to the greywackes of the Selwyn Gorge, stated that they were the oldest

representatives of the Palaeozoic strata of the Malvern Hills (8, p. 63). At the same time he remarked that the particularly incoherent matrix of the conglomerates, and the general nature of their component pebbles, would almost suggest that they consisted of post-Pliocene alluvium. He noted, too, the occurrence of plant-beds in which he obtained species of *Taeniopteris* and *Pecopteris*; but, being unable to reconcile the presence of *Taeniopteris* with his classification of the Cairn Range beds as Upper Palaeozoic, he held that its occurrence did not outweigh the stratigraphical evidence (8, pp. 6–7).

There is, then, no doubt that there is an unconformity between the beds of the Cairn Range and the greywackes, and that the latter are the more ancient rocks. This is not merely a local break in the sequence, because the greywackes are found to lie unconformably below the conglomerates of the Cairn Range type in many places in this part of the Malvern Hills.

The fossil flora of the Cairn Range has been described by the late Dr. E. A. N. Arber from specimens collected from the plant-beds by Professor R. Speight (*N.Z. Geol. Surv. Pal. Bull. 6*, p. 11). Arber considered these beds to be Lower Jurassic, though, as he remarks, "were a more extensive flora known from them, this conclusion might well require revision."

C. *Mount Misery Rhyolites.*

Mount Misery (1,910 ft.) is a dome-shaped mass of rhyolite rendered somewhat irregular in outline by erosion. Its western slope is marked by the steep fault-scarp which has determined the position of the coal-measures at its foot. On the summit are massive projecting rocks which would almost suggest extensive dykes, but the general lithological resemblance of all the rocks renders this unlikely. Mount Misery was obviously not a volcano of the ordinary explosive type, but probably was formed by slow accretion of a viscous lava by endogenous growth. Hutton referred the lavas to the "massive accumulations of Richthofen" (11, p. 41) From the summit of the mountain an easy descent is made to two lower ridges of rhyolite containing well-preserved garnets. Lying against the south-eastern side of the mountain is a great sequence of coaly shales and rhyolitic conglomerates.

Examination of thin sections of the rock from several points shows some slight variations in type. Some are rich in garnets, which are absent in others. Many of the sections exhibit a glassy base in which flow-structure may or may not be apparent; others have a groundmass which is completely though minutely crystalline and shows no evidence of fluxion. Cox (3, pp. 107–9) describes several examples of rhyolite from various localities, and considers that some possess an isotropic vitreous groundmass, while in others he remarks on the "devitrification" of the groundmass and the absence of flow-structure.

In some sections the groundmass consists of a micro-crystalline complex of quartz and feldspar too minute for individual identification, while in others it is almost completely isotropic with a dull felsitic appearance. In several the larger particles of the groundmass give a somewhat tufaceous appearance. The phenocrysts include quartz of very variable sizes, often showing considerable corrosion at the edges and somethmes a distinct brecciation, suggesting movement while cooling. Orthoclase is an abundant constituent, with rare plagioclase. Garnets, if present, are clear and well

preserved, or completely weathered to a deep-brown ferrous substance like haematite. Biotite in scattered flakes may show alteration to magnetite, which seems always present in scattered grains or secondary patches.

The age of the rhyolites seems definitely fixed as Cretaceous, since, as Cox observed (3, p. 39), rhyolite tuffs and conglomerates occur interstratified with Cretaceous coals. But Marshall (14, p. 21) refers all this series of acid and intermediate rocks to his Trias-Jura system, while Park considers that the date of their eruption lies between the close of the Jurassic and the commencement of the Eocene (15, p. 83).

D. *Coal-measures.*

Discontinuous fragments of the "Cretaceo-Tertiary" coal-bearing series occur in many places in the neighbourhood, but in Cordy's Flat workable coal is found at—

(*a.*) Hart's Coal-pit—situated on the northern (or left) bank of the Selwyn River, just below the entrance to the gorge.

(*b.*) Hill's Coal-pit—on the Steventon Estate, in the central portion of the flat.

(*c.*) St. Helens Coal-pit—locally variously known as Wilson's, Levick's, or Sutherland's—at the north-western base of Mount Misery, in the valley of Glendore Stream.

These occurrences obviously represent remnants of a former more widespread field of a somewhat lenticular shape. That they now occupy the floor of the basin must be ascribed to the Cordy's Flat fault, on the downthrow side of which they lie. The comparatively elevated St. Helens seams, in close proximity to the fault, and the lower, more distant beds at Hill's coal-pit point to differential downthrow, which, greatest in the centre, probably determined the rudely semicircular form of the field. Hart's coal is quite isolated from the rest, the Selwyn River and the Manuka Creek having removed any pre-existing connecting beds and deposited a great depth of alluvial gravel. If coal-measures yet exist beneath these gravels, the remnants will be so small and will cut out so quickly against the fault as to make them not worth practical consideration. Snob's Hill, in the centre of the flat, has been prospected for coal, but has been found everywhere to consist of gravel.

Remnants of the "Cretaceo-Tertiary" sediments lie to the south-east of Mount Misery, stretch across the Selwyn River at the rapids, and bend south-eastward, again to become coal-bearing in Surveyor's Gully, behind Glentunnel Township. Hector (10, p. 53) thought there were two distinct and separate coal-bearing formations in the Malvern Hills, while Haast consistently refers to the Cordy's Flat coal-measures as an outlier of the main measures of the district. The weight of evidence is in support of Haast's view. The coal-bearing beds are everywhere of a remarkably uniform fineness of grain, suggesting deposition in shallow estuarine waters of sediments derived from a land of low relief.

Hart's Coal-mine.—An outcrop of the coal-measures is visible in the bend of the Selwyn River near the Springfield road-crossing at the north-east end of Cordy's Flat. Here an intrusion of dolerite has lent protection from erosion. The sequence at this place is somewhat obscured by debris from the old mining drives, and the dip of the strata has been

much disturbed by the intrusive rock. The beds exposed are as follows, in ascending order :—

1. (1.) (Lower) Sandy shales, 8 ft. Baked white or greyish-white along whole length of exposure.
   (2.) Carbonaceous shales, 8 ft. Less metamorphosed than preceding.
   (3.) Sand and sandy shales, 20 ft. Contain bands of impure lignite. These strike north and south (magnetic), and dip E. 5°. Farther up the river the strike is north-north-east, and dip E.S.E. 20°.
   (4.) Surface gravels, 8 ft.

From here to the base of the Cairn Range the following sequence is encountered :—

2. White quartz sands, streaked and stained by iron oxide, which strike north-east, and dip uniformly S.E. 30°. These sands are used to some extent for moulding purposes. Together with the underlying shales they have a total thickness of 300 ft.
3. Calcareous sandstone, slightly glauconitic. Strike, N. 40° E.: dip, E. 30°. These cap the ridge above the sand.
4. Sands, 200 ft.
5. Calcareous sandstone, passing down into a band consisting almost entirely of remains of *Conchothyra parasitica* Hutton, exposed in the gully at the foot of the Cairn Range.

Hart's coal-mine has long been abandoned, though it attracted the attention of the early geologists on account of the semi-anthracitic nature of the coal altered by the dolerite sill. This coal was soon worked out, but the reports mention the discovery of a thick seam of good brown coal, which was not mined on account of the water encountered.

Hill's Coal-mine.—A long ridge not rising more than 150 ft. above the flat, and extending from the front of the Steventon Homestead to the present workings, is composed for the greater part of its length of the basal beds of the Cretaceous series, but no actual contact with the greywackes is visible. A small exposure in a little gully opposite the wool-shed shows the following beds, in ascending order :—

(1.) Sandstone—thick, red, highly ferruginous.
(2.) Clays.
(3.) Black shales 1 ft. 6 in. thick, containing compressed shiny plant-remains, and having conchoidal fracture.
(4.) Fireclay, typically hard, with concretions of ferruginous sandstone.

These strata dip S.E. 30°, and have a total thickness of about 60 ft. No further outcrop is seen for a long distance, but the beds exposed in prospecting-shafts sunk in various places by the present owner of Steventon have uniformly a dip of 30° S.E., and a total thickness of at least 760 ft.

As a result of this prospecting a permanent drive dipping south-east at 20° was opened. It passed through an irregularly vertical wall of dolerite, 8 ft. thick, at 17 ft. from the entrance. This is probably an upward extension of a sill, and it turns over near the roof, apparently to continue as a sill on an upper level. Immediately beyond the dolerite is a 3 ft. 6 in. seam of brecciated altered coal, increasing in thickness to 3 ft. 9 in. This drive opened up a good seam of a very fair quality brown coal, which has since been worked extensively.

At the foot of the ridge is the entrance to a drive excavated in 1871, and described by Haast in his report of that year (8, pp. 51–52). Though about 400 tons of coal was mined from a shaft near this point, the field seems to have been abandoned early, for no mention of it is made in Lindop's reports of 1885. The present owner of the property had the drive reopened, thus providing a good opportunity for re-examination of the relations between the coal-bearing beds and the intrusive igneous rock, by which they have been much altered. Haast concluded that, contemporaneous with the deposition of the coal-beds, there were flows of basic lava, above which shales and coal-seams were subsequently deposited. Though a detailed description of the drive is rendered unnecessary by that of Haast, examination shows that the dolerite is not the remnant of successive lava-flows, but represents a single large intrusion. The following observations made in the old drive support this view:—

(*a*.) Though the intrusion conforms generally to the bedding-planes of the strata, in several places it breaks across them vertically, to continue on a higher level.

(*b*.) Numerous projecting veins and tongues of igneous rock pass both upwards and downwards into the neighbouring beds. The intrusive rock itself shows a rude polyhedral parting on both upper and lower surfaces.

(*c*.) The underlying and overlying beds are equally altered by heat and pressure. Coal in contact with the intrusion has a highly developed columnar structure, and is semi-anthracitic above and below.

(*d*.) Where the intrusive rock has passed through beds of coal or carbonaceous shale it is itself completely altered to a dull-green earthy mass. The dip of the beds is very irregular at many points.

(*e*.) Many of the marginal columns of coal and indurated shale show a bending towards the inner end of the tunnel. If this be taken as indicative of direction of flow, the rock must be regarded as intrusive.

St. Helens Coal-mine.—This mine is not mentioned in Haast's reports on the Malvern Hills, nor did Cox refer to it in his reports of 1877–78, though he then inspected all the mines in the neighbourhood. In 1883, however, Cox mentions it as "Wilson's mine," giving a section showing what he thought to be a north-easterly extension of the Brockley dyke, which he expected to have a metamorphic effect on the brown coals (3, p. 34). A. N. Lindop gives a brief account of workings here (13, p. 17). There seems to be no evidence whatever of a continuation of the Brockley dyke as suggested by Cox.

The whole area has been prospected in recent years, and many old workings have been reopened. Data obtained from these explorations correspond roughly with Lindop's description. He, however, had taken no account of an 8 ft. seam some 40 ft. below the level of those previously worked. The seam recently worked here, known locally as "Wilson's seam," is 5 ft. to 6 ft. thick. An old dip drive following the seam was reopened and then continued, levels in the coal being set off at 124 ft., 160 ft., and 200 ft. from the surface. Overlying this seam there is about 15 in. of a poor fireclay, followed by 15 in. of coal, and a little above this there is a further 3 ft. to 4 ft. of coal with a band of ironstone 6 in. from the roof. There is a coal-seam 4 ft. to 5 ft. thick a little below Wilson's seam, with an 8 ft. seam about 40 ft. lower. The coal-seams here dip uniformly at 30° to the south-east, but terminate in that direction at the Cordy's Flat fault, which brings the coal-measures against the Mount Misery rhyolite.

Intrusive Igneous Rocks in Coal-measures.—These are exposed at the workings of both Hart's and Hill's coal-pits, and have been referred to previously as doleritic intrusions penetrating the coal. Haast mentions the association of coal with igneous rock at Hart's mine in his report of 1871 (8, p. 52). He gives (8, p, 16) a plan and a section indicating that he considered the intrusion which has caused the alteration of the coal to be a large vertical dyke striking S. 15° E. to N. 15° W. (magnetic), with a thickness of some 18 ft. Examination of the locality on several occasions has failed to reveal any evidence in support of this description, and the direction of strike given by Haast cannot be inferred from the only outcrop now visible. He may have observed the loose weathered and rounded dolerite boulders which occur for a hundred yards along the river-bank, thereby arriving at an approximate north-and-south direction, but these boulders are obviously not *in situ* and their presence here is quite fortuitous.

The one outcrop of igneous rock as seen at the bend on the river-bank is so small that no definite statement as to the size and extent of the intrusion can be made. The underlying strata cannot be seen, but the upper surface of the dolerite is in contact with a clay bed dipping S.E. 30° and showing every indicarion of having been baked. Also, just round the point, a sandy shale is found to lie almost flat, and to be considerably baked and hardened. Comparison with the dolerite at Hill's mine, and the absence of any other igneous rock except the boulders previously mentioned, indicate that the intrusive is not a dyke, but a sill lying between the bedding-planes of the strata and dipping with them S.E. 30°. There seems no reason to doubt that the dolerites of Hart's and Hill's mines belong to the same sill, their extension across Cordy's Flat being obscured by river-erosion and gravel-deposition. Haast (8, p. 51) states that the "dyke" of dolerite (also described elsewhere as "interbedded sheets") exposed in Hill's mine forms also the eastern corner of Mount Golgotha. This seems very probable, for, though the outcrop observed by Haast has since been obscured by cultivation, isolated small blocks of dolerite have been found here. The occurrence of basic sills in New Zealand is not common, and the only reference to them so far as the Malvern Hills district is concerned is that made by Park regarding their effect on coal (16, p. 50).

Examination of thin sections of the igneous rocks from Hart's and Hill's mines show that they are holocystalline dolerites of medium basicity. Hutton (12, p. 130) describes the rock from Hart's as an augite porphyrite. But the igneous rocks are distinctly not porphytitic in structure, and the occurrence of olivine and labradorite, the holocrystalline even-grained structure, and the doleritic relations of the augite and feldspar leave no doubt as to their proper classification as dolerites. The rock from Hill's shows labradorite in laths and small crystals of uniform size, ragged crystals and grains of augite sometimes completely enclosed by feldspar laths, olivine, magnetite, and various alteration products. That fron Hart's is remarkable for abundant calcite, the highly altered nature of the rock suggesting this to be secondary, as much of it occurs in veinlets due to infilling of cracks.

Effect of Igneous Intrusions on Coal.—At Hart's mine the high-grade coal due to the intrusion of dolerite into the coal-measures has been entirely mined, but at Hill's mine a bright semi-anthracitic coal is still observable. Where in contact with the dolerite sill it is generally characterized by brecciation and columnar jointing, and by being bright, hard, and clean to the touch. But within a comparatively short distance from the sill which has been responsible for the alteration it approaches more and more

to the original type of brown coal. A good many analyses of samples of the altered coal are available. These show the general nature of the alteration, with a gradation from anthracitic coal to altered brown coal to normal hydrous brown coal (10, p. 54; 7, p. 140; 9, p. 19; 6, p. 565). The alteration of the Cordy's Flat coals is not such as to produce the property of coking, and they merely approximate to the anthracitic type. They are simply brown coals modified only in close contact with intrusive rocks by the loss of water, or volatile hydrocarbons, or both. The extreme product of alteration in contact with the neighbouring Brockley dyke is a natural coke.

Age of Dolerites.—The date at which the dolerites were intruded into the coal-measures cannot be definitely stated. They are certainly very deeply weathered, but this may be no indication whatever of an early Tertiary or a pre-Tertiary age. No assistance is to be obtained from correlation with the basaltic flows of the neighbourhood, for the age of these is equally uncertain. Although the only definite statement which may be made is that they are post-Cretaceous, they are probably to be associated with the earth-movements of the Pliocene, and therefore in the absence of evidence to the contrary they are here assigned to the later Tertiary.

Rhyolitic Conglomerates, and associated Sandstones and Shales.—Conglomerates formed largely of rhyolite pebbles, interstratified with more or less ferruginous sandstones and shales, some layers of which are highly carbonaceous, are exposed on the eastern and south-eastern slopes of Mount Misery, and at Precipice Hill, where the sequence attains a thickness of several hundred feet. These beds are well seen in the small creek which comes down to Glendore Stream past the old Mount Misery homestead-site. At the entrance to the gully sandstones with ferruginous concretions are overlain by shales dipping south-east at 5°–10°. At the first waterfall, a few chains above this, the sequence is exposed to a lower band of ferruginous shales with indistinct plant-remains, surmounted by a fine sandy conglomerate passing up into a hard compact sandstone. These beds dip S.E. 20°. Just below the old homestead-site is the horizon of the rhyolitic conglomerates. Cox (3, p. 30) described tufaceous beds resting against the flank of Mount Misery in this locality, but there is no reason to regard these beds as tuffs. The pebbles, thoroughly rounded by water, do not consist exclusively of rhyolite fragments, many of them being greywacke. Moreover, the uniformly fine-grained sandy matrix, the abundant lenticular inclusions of coaly substance, and the interstratification with shales and sandstones all suggest that they are ordinary conglomerates, the rhyolite pebbles of which may well have been derived from the rock forming Mount Misery. The conglomerate band at this point attains a thickness of 35 ft., and dips at 30° to the east-south-east, a dip which is maintained up the stream until rhyolite appears. Underlying this thick band is a bed of coaly shale containing a large lenticular mass of conglomerate. From here is a succession of hard conglomerate bands, alternating with soft shaly layers, giving rise to a series of steps, over which the stream flows. The actual contact of the sedimentary beds with the massive rhyolite is not distinguishable, but the latter is encountered just past the second ridge and continues to the head of the stream.

A magnificent exposure at the steep cliff of Precipice Hill facing the Selwyn River, north of Whitecliffs Railway-station, shows a great thickness of black coaly shales with intermittent thin bands of ferruginous and concretionary sandstones, passing up into a thick band of finer and coarser

rhyolitic conglomerates, with a recurrence of the shales and sandstones above. The structure here is highly interesting and demands careful consideration. The strata seen in the cliff dip west towards the Selwyn and form the eastern limb of a large synclinal fold. Some 150 yards from the face of the precipice, sharply tilted beds of hard reddish sandstone—a sandstone generally occurring at the base of the local Cretaceous—are seen to strike north and south (magnetic) and to dip 40° E. Fifty yards nearer the precipice hard sandy shales and sandstones with a dip of 40° E. are exposed. Thirty yards nearer similar hard sandy shales are seen to lie almost horizontally. Beneath the Selwyn River Bridge the same bed dips 40° E., but the strike is now slightly west of north, owing to synclinal twisting. Fifty yards below the bridge the same beds show a north-west strike.

These observations, together with the westerly dip of the Precipice Hill beds, supply the key to the structure, and there seems no doubt that the Selwyn River here flows over another syncline. The half-mile stretch from Precipice Hill to the eastern slopes of Mount Misery is mantled with alluvial gravels, but, since the basal beds of the local Cretaceous are exposed in the river, these gravels are probably not very thick.

The Upper Senonian age of the local coal-measures has been fully discussed in connection with fossil remains from Cordy's Flat and the Selwyn Rapids (20, pp. 294–305, 337–42; 22; 21, pp. 260–65; 23, pp. 539–44).

E. *Post-Pliocene Gravels.*

The grading of the Selwyn River channel after the successive periods of uplift to which the country was subjected has left thick mantles of greywacke gravels in various elevated places in the neighbourhood. These, together with the very coarse gravels comprising Snob's Hill, in the centre of Cordy's Flat, must be assigned to the older (Kowai) series of gravels (19). The formation of Snob's Hill is to be attributed to a partial infilling of the depression by material brought down from the upper gorge by a river of much greater velocity than the Selwyn has at present. Subsequently much of the gravel was removed during a period of erosion, leaving Snob's Hill as an isolated elevation. Down-cutting, owing to decreased volume of the river and its reaching a base-level across the flat, has now practically ceased.

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Raised Beaches in Teviotdale District, North Canterbury.

By G. JOBBERNS, M.A., B.Sc., Christchurch Training College.

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IN view of Dr. Henderson's recent paper on the post-Tertiary coastal features of New Zealand (*Trans. N.Z. Inst.*, vol. 55, pp. 580–99, 1924), the following note on raised beaches is compiled from observations of the coast between the Motunau and Waipara Rivers. The terraces here are so well defined that they may often be seen distinctly from the Port Hills across Pegasus Bay, and they have previously been briefly described by Professor Speight in his paper on the Lower Waipara Gorge (*Trans. N.Z. Inst.*, vol. 44, pp. 221–33, 1912). Though intermittent uplift is clearly indicated along this coast, erosion has been so rapid as to cut away much of the original seaward extension of the lower terraces. For this reason it is very difficult to get any definite correlation between the river-terraces and the remnants of wave-levelled coastal platforms in the same district. The object of this paper is to record the heights and distribution of those platforms which are of marine origin.

THE DOVEDALE AREA.

The coastal marine terraces are divided into two groups by the Limestone Range, which reaches the coast about midway between the mouths of the Waipara and Motunau Rivers. This range, capped by a tilted and faulted block of Weka Pass limestone, extends from a point about three miles south-east of the Waipara Railway-station to the sea, through Montserrat, whence the limestone swings inland, continuing past Vulcan Hill to the north of the Motunau River.

To the north of the bluff, where the limestone forms a steep white cliff, the perfect shore-platform of the Motunau widens out rapidly; but the present paper is concerned only with the series of platforms to the south of the bluff. These are most clearly defined in the Dovedale area, where an extensive shelf, capped everywhere by marine shell-bearing gravels, resting unconformably on slightly tilted marls and sands, has the shape of a segment of a circle. It widens out southward from the limestone bluff, reaching its maximum width near the mouth of the Dovedale Stream, and then tapers to a point towards the mouth of the Waipara. Whereas in the south it is deeply dissected by a series of parallel juvenile consequents, most of the drainage in the north is tributary to the Dovedale Stream. This results in the preservation of a remarkably uniform line of coastal cliff, and such a decrease of height inland as to allow the accumulation of water in three permanent lagoons on the portion known as Bob's Flat.

The coastal cliff increases in height from 180 ft. (the actual height of a superimposed stream-terrace) at the mouth of the Dovedale Stream to 370 ft. where the shore-platform tapers out against the limestone bluff of Montserrat. Since all the terraces of the area rise inland, this remarkable increase in the height of the cliff and the narrowing of the platform behind it suggest that to the north the platform was once very much wider, but has been cut back by the sea.

Immediately above Bob's Flat a remarkably well preserved and uniformly high remnant of a marine cliff runs almost parallel to the present shore-line. This shows a height in front of 650 ft., and is no doubt the former seaward edge of a raised beach extending back to the stripped dip-slopes of the Limestone Range. This older terrace is notably more dissected than those at a lower level, but, owing to the drainage being again tributary to the Dovedale stream, the seaward scarp is very uniform and not dissected by stream-channels to any considerable extent. At Amuri Bluff McKay has recorded the occurrence of marine platforms with Recent marine shells at a height of 500 ft. (*Rep. Geol. Explor., 1874–76*, p. 177), so if this terrace be a true marine platform its height is greater than any hitherto recorded on this part of the coast. At a point above Trig. D north of the mouth of the Waipara a doubtful platform-remnant preserved by a cap of hard conglomerate rises from 650 ft. to 700 ft.

The Mouth of the Waipara.

In this locality Professor Speight has described a wide coastal plain extending southward several miles (*Trans. N.Z. Inst.*, vol. 44, map, p. 223). At the river-mouth this is at least a mile and a half in width, rising in this distance to a height of 35 ft. at the base of the old sea-cliff on the south bank of the river. In places occupied by swamp this plain is little above sea-level, and its very recent emergence is suggested by the occurrence of patches of well-preserved mussel-shells. On the south bank of the river the top of the old sea-cliff is 85 ft. above the juvenile coastal plain, or 120 ft. above sea-level. From here a wave-cut bench rises inland 165 ft. at a point on the Teviotdale Road. The highest part of the inner edge of the platform is slightly higher than this. At the trig. station north of the river the sea-cliff is still 120 ft. above sea-level, but rises northward in stages to 150 ft. and 210 ft., which is approximately the height of some of the lower remnants along the coast.

New Shells from New Zealand Tertiary Beds: Part 2.

By H. J. FINLAY, M.Sc., National Research Scholar in Palaeontology.

[*Read before the Otago Institute, 10th June, 1924; received by Editor, 31st December, 1924; issued separately, 13th March, 1926.*]

Plates 55–60.

Tugali pliocenica n. sp. (Plate 59, figs. 1–5.)

Shell ancestral to *T. colvillensis* Iredale and Finlay MS.,* but not so high and compressed, with hardly any dorsal carina, squarish and not pointed in front. Radial ribs moderately wide behind, narrower in front, but interstices everywhere wider and ornament more fenestrate than in *T. elegans* Gray, from which the new species differs also in much smaller size and more conic shell, less widened behind. Sinus rib soon trifurcate, and remaining so to margin. Margins as in *colvillensis*, more finely denticulate than in *elegans*.

Length, 18 mm.; height, 6 mm.; width, 11 mm.

Locality.—Castlecliff blue clays (Castlecliffian); not uncommon.

Type in Finlay collection.

Tugali navicula n. sp. (Plate 59, figs. 6–9.)

Shell very elongate, rather depressed, with coarse sculpture, apex well behind. Numerous rather coarse axial ribs, regularly alternately stronger and weaker, reticulated by coarse wavy concentric ribs, interstices with triangular nodules, leaving irregularly-shaped pits between. Sinus rib soon trifurcating and remaining so to margin. Apex at posterior fifth of length, low, hardly hooked. Sides parallel, regularly rounded behind, more narrowly so in front. Margin with very weak but broad denticulations, reduced almost to short grooves on outer edge. Muscle-scars sunken, strong, sides long. Groove wide and shallow, distinctly notching margin.

Length, 17·5 mm.; height, 4 mm.; width, 9 mm. (type). Length, 25 mm.; height, 8 mm.; width, 13 mm. (paratype).

Localities.—Target Gully "shell-bed" (Awamoan); several specimens. Also Ardgowan.

Type in Finlay collection.

Easily separated from Recent and other fossil forms by narrowly-elongate depressed shell, coarser sculpture, more posterior apex, and different marginal denticulations.

Nobolira n. gen.

I provide this for a series of shells very similar to *Lironoba*, but with a spirally lirate protoconch, and name as type *Lironoba polyvincta* Finlay (*Trans. N.Z. Inst.*, vol. 55, p. 485, 1924). When discussing this group of

* In this paper, references to "Iredale and Finlay MS." are to a systematic and nomenclatural paper which was intended to appear in this volume, but has been held over.

Rissoids I commented on the discrepant apex of the two fossil species I described, and noted that there seemed to be two parallel groups of these heavily-ribbed forms, exactly as in the case of *Merelina* and *Linemera*. Since then I have seen abundant topotypes of *L. suteri*, the genotype of *Lironoba*, and my impressions are confirmed. *L. suteri* has a smooth, rudely-coiled apex, with strong upper carina, and seems related to *Anabathron*, which has the same texture but several keels on apex, and dense axial foliations on whorls. The *polyvincta* group is a northern one and is different altogether, having only the heavy spiral ribs in common with its southern twin, otherwise the general facies is quite different; the apex is loosely coiled, with numerous strong spiral grooves but no keels. I have numerous undescribed Recent species, all from the north, while probably most of the Australian species referred to *Lironoba* would be better placed here. The anagrams *Linemera* and *Nobolira* will be useful in recalling the genera they simulate in superficial appearance.

Onustus prognatus n. sp. (Plate 59, figs. 15, 16.)

Very close to the Recent *neozelanicus* (Suter), but considerably more depressed in relation to width. Finer wavy sculpture on whorls. Incremental lines on base finer and much less lamellose. All specimens seen have greater part of whorls uncovered, and only a row of small contiguous stones at sutures.

Height, 44 mm.; diameter, *circa* 70 mm.

Locality.—Wharekuri greensands (Ototaran ?); type. Also from Clifden, Southland, band 3 (Ototaran).

Type in Finlay collection.

Struthiolaria prior n. sp. (Plate 56, fig. 17.)

Ancestral to *S. subspinosa* Marwick, but differing from it in lower peripheral keel (medial on spire-whorls instead of on upper third), leading to a much steeper shoulder and consequently different outline of outer lip. Finer spiral sculpture (threads hardly at all raised, and very thin, interstices many times their width), and coarser nodulation on lower keel on body-whorl (about 9 knobs over its length instead of 12).

Height, 61 mm.; diameter, 39 mm.

Locality.—Waikaia, in shelly limestone (Ototaran ?); two specimens.

Type in Finlay collection.

Included by Dr. Marwick in the list of records of *S. subspinosa* as "Waikaia (H. J. Finlay)" (*Trans. N.Z. Inst.*, vol. 55, p. 175, 1924), but I think there are valid differences.

Magnatica altior n. sp. (Plate 60, figs. 3, 4.)

This shell accompanies *M. suteri* Marwick in the Wharekuri beds, but is much rarer. Easily distinguished by its much higher mamillate spire and different umbilicus. General shape that of *Uber*, greatest tumidity low down. Sides of spire and upper part of body-whorl practically straight. Sutures distinct. Aperture oblique. Umbilicus situated low down, narrow but quite pervious and funnel-shaped, not rude and irregular as in *M. suteri*. A callus-lobe spreading round it above, and into it as a rather thick low funicle; below this a second very thin sharp ridge, a depression between the two. Whorls not nearly so vertically compressed as in *suteri*. Aperture much more oblique and shell more conic than in *M. sutherlandi* Marwick.

Height, 26 mm.; diameter, 22·5 mm.

Locality.—Wharekuri greensands (Ototaran ?); a few specimens.

Type in Finlay collection.

This species reaches at least three times this size, but no perfect large specimens have been seen. Marwick (*Trans. N.Z. Inst.*, vol. 55, p. 555, 1924) comments on the presence of two forms at this locality, and his fig. 5 (*loc. cit.*, pl. 56) seems to represent a large specimen of *altior*.

Magnatica clifdenensis n. sp. (Plate 60, fig. 3.)

Allied to the last by its high spire and small pervious umbilicus, but differing in the whorls being slightly depressed below suture, thus forming a rather stepped spire. Base is more produced, and basal lip more narrowly rounded. Umbilicus almost a perfect oval, funicle from callus-pad being obsolete; instead of a thin sharp ridge there is a deep narrow funicular groove, slightly indenting margin. Aperture decidedly oblique.

Height, 35 mm.; diameter, 28·5 mm.

Locality.—Clifden, Southland, band 6B (Ototaran ?); one specimen.

Magnatica rectilatera n. sp. (Plate 60, fig. 5.)

Distinguished from *M. suteri* Marwick by its rather straight outlines above and below shoulder. Spire short, flattened, but slightly tabulate, whorls distinct; keel bluntly rounded, thence very flatly convex till near base, which is suddenly contracted. Umbilicus circular, deeply pervious, almost perspective; callus funicle almost obsolete, the lower thin sharp ridge very strong; margin of umbilicus not rounded as in the two previous species but bluntly carinate.

Height, 21 mm.; diameter, 19 mm.

Locality.—Awamoa blue clays (Awamoan); type specimen. Also from Target Gully and Rifle Butts; one specimen from each.

Type in Finlay collection.

Possibly Dr. Marwick's record of *M. suteri* from Awamoa refers to this species.

The last three forms and *N. sutherlandi* Marwick have a more conic spire and lower cylindrical and pervious umbilicus than in the *suteri-approximata* line. I would treat *Magnatica* as a genus, and propose *Spelaenacca* nov. (type, *Magnatica altior* nov.) as a section for these forms.

Uber laxus n. sp. (Plate 60, fig. 1.)

Shell large, very wide and spreading; spire rather blunt, less than quarter height of aperture with callus, whorls 5, very rapidly increasing, surface polished and with smooth appearance but showing growth-lines and faint spiral striations. Suture tangential. Aperture widely semi-lunar; outer lip sinuous, slightly concave in middle; inner lip with thick parietal callus, filling umbilicus all but a semicircular moderately deep furrow (which does not enter the aperture), and cemented to parietal wall along whole outer side; umbilicus with funicle hidden.

Height, 34 mm.; diameter, 32 mm.

Locality.—Clifden, Southland, band 8 (Awamoan ?); one specimen.

Related to *U. chattonensis* Marwick, but lower and wider, umbilicus not pervious, &c. Relative to width of whorls and umbilicus, and size of callus, this is the widest *Uber* known from New Zealand. *U. intracrassus* Finlay and *U. waipipiensis* Marwick are as wide, but have the aperture forced outwards by a huge callus and a wide umbilicus respectively.

Globisinum crassiliratum n. sp. (Plate 60, fig. 6.)

Closely allied to *G. miocaenicum* (Suter), and found with it (though much rarer), but differing at sight in higher spire and coarser sculpture. Spire about half height of aperture; sutures cut in, slightly channelled. Spiral cords of very irregular width, about 12 on penultimate whorl, flat, with furrowed interstices also of quite irregular width, but generally narrower than cords. Umbilicus and aperture as in *miocaenicum*.

Height, 13 mm.; diameter, 11·5 mm.

Localities.—Otiake, sandy beds above the limestone (Awamoan); two specimens. Also one shell from Wharekuri.

Type in Finlay collection.

Euspinacassis pollens n. gen. et sp. (Plate 55, figs. 10–12.)

Shell large, massive, encircled with rows of strong high tubercles; aperture heavily thickened, canal very short, deeply notched behind. Apex symmetrical, dome-shaped, of 3 smooth regularly-coiled whorls, nucleus minute. Four spiral rows of nodules on last whorl, only the uppermost showing on spire-whorls; 11–13 strong pointed upwardly-directed spines per whorl on top row, about 17 lower blunter nodules on second and third rows, and many weak very low nodules on lowest row; 6–8 low spiral cords on base; whole surface overlaid by very numerous close undulating spiral grooves, interstices slightly raised as weak threads. Spiral threads coarser and plainer and fenestrated by numerous thin axial threads on early spire-whorls. Spire rather high, about half height of aperture, outlines straight. Whorls medially sharply angled by nodular keel, slightly concave above and below, strongly concave between nodular rows on body-whorl. Suture strongly undulating, a little cut in. Aperture in young shells distinctly phalioid, outer lip being thickened and reflexed and bearing several denticles below, inner lip merely a thin glaze over parietal wall and pillar, but free across excavation above fasciole and forming there a small but pervious umbilicus; pillar irregularly plaited and ridged, with one stronger medial blunt ridge later forming outer margin of fasciole. Adult shell has sides of aperture enormously thickened, outer lip very strong and with thickly laminate reflexed edge; inner lip spreading as a massive parietal callus almost up to top nodular row, and as a thick free edge across umbilicus and pillar, forming another umbilicus on farther side of fasciole; pillar with numerous anastomozing sharp plaits and ridges, fasciole ridge covered. Canal very short, at once bent to left and slightly backwards by a strong deep notch almost exactly as in *Phalium.* Adult shell has a second projecting varix emerging obliquely from parietal callus. Fasciole with an anterior bluntly angular ridge, bounded behind by a sharp keel, a deeply-hollowed rounded groove immediately behind it, leading into umbilicus.

Height, 69 mm.; diameter, 55 mm. (type). Height, 39 mm.; diameter, 27 mm. (paratype). Height 27 mm.; diameter, 18·5 mm. (paratype).

Locality.—Clifden, Southland, band 6A (Ototaran ?); four specimens.

Type in Finlay collection.

Congeneric with and very closely allied to *Cassis muricata* Hector (*Prog. Rep. Geol. Surv. N.Z.*, vol. 9, p. 4), a shell I have not seen, but which Dr. Marwick assures me is distinct. He has (this volume, p. 319) described a shell under the name *Phalium grangei* n. sp., remarking that it has rows of strong knobs, and that "strong sculpture was used as the basis of *Echinophoria* Sacco, but Cossmann does not think it worth recognition." In any case, *Echinophoria* is preoccupied. *Cassidea* and

Semicassis both merit recognition, and the new species does not fall comfortably into either, the type of sculpture and aperture being distinctive, while at the same time it seems a rather obvious derivative of the *Casmaria* series (or *vice versa*). The step is therefore taken of providing for it, *muricata* Hector, and *grangei* Marwick a new genus—*Euspinacassis*.

Cirsostrema caelicola n. sp. (Plate 57, figs. 17, 18.)

Shell stout, large, elaborately sculptured. Apex lost. Twelve stout and high minutely-frilled axial ribs per whorl (interstices 1½–2 times their width), suddenly deeply cut in and smoothed below suture and prolonged slightly forward there; diminishing in width but hardly in height on base. Varices marked by stouter ribs (about twice width of ordinary ribs), quite irregular in disposition. Eleven stronger and wider spirals per whorl, with a narrower thread between each two, and sometimes a minute threadlet on either side of it: a few fine threads near suture and basal keel; base with regular narrow threads with sublinear interstices; spirals smooth in interstices, lamellose over axials. Base flat, with a strong outer keel (bisected by a linear groove and raised more in interstices than on axial ribs). Spire tall, regularly tapering, whorls convex; sutures concealed by expansions of axial ribs, but seeming canaliculate because of excavation at top of ribs. Aperture almost circular, outer lip thick, frilled, and crossed by spiral cords down to basal keel, thence quite smooth and polished along wide and flat basal lip to rounded triangular pad marking end of stout fasciole encircling pillar. Peristome complete, inner lip thin but well defined and blunt, regularly curved.

Height, 49 mm.; diameter, 21 mm.

Locality.—All Day Bay blue clays (Awamoan); one specimen.

Type in Finlay collection.

A most beautiful shell. Closely related to *C. lyrata* (Zittel), but wider and with far more numerous spirals; especially characteristic is the pseudo-canaliculation of the suture, caused by the concave truncation of the ribs.

Notacirsa n. gen.

I provide this for *Turbonilla oamarutica* Suter (*N.Z. Geol. Surv. Pal. Bull. 5*, p. 16, 1917). Suter's original location was in section *Pyrgiscus* of *Turbonilla*; Cossmann (in Marshall, *Trans, N.Z. Inst.*, vol. 49, p. 462, 1917) remarked that it was probably an *Acissella* [*sic*]; and I noted (*Trans. N.Z. Inst.*, vol. 55, p. 506, 1924) that it was much better referred to the Epitoniidae than to any Pyramidellid genus. It has an oval aperture as in *Acirsella*, but an ornament more like *Hemiacirsa*, from which it also differs in its rounded periphery. *Epitonium elatum* Suter, *E. gracillimum* Suter, and several undescribed Tertiary species may be named as congeneric. As Suter's original drawing does not well convey the appearance of this shell, I present a much magnified figure of a topotype in my collection (Plate 56, fig. 16). The Aldingan *Scalaria (Hemiacirsa) lampra* Tate (*Trans. Roy. Soc. S. Aust.*, vol. 13, p. 234) is also congeneric.

Iredalula n. gen. Type: *Bela striata* Hutton.

This characteristic New Zealand Pliocene shell presents a most striking similarity to *Acamptochetus mitraeformis* (Brocchi) (Cossmann, *Essais de Pal. Comp.*, liv. iv, p. 123, 1901), but the resemblance is quite superficial,

as a glance at the embryos will reveal. *Acamptochetus* has, in Cossmann's words, the "protoconque lisse, paucispirée, formant un gros bouton à nucléus subdévié"; *B. striata* has a curiously-shouldered disproportionately-whorled embryo, the tip globular and a trifle inrolled, the remainder with a high blunt keel, shoulder wide and flat, straight below; obscure cord-like lirations (two more prominent on the keel) are very faintly reticulated by growth-lines, but the whole is smoothish and polished. The canal and whorling are also somewhat different. The shell itself is, in the fossil state, pure white and extremely elegant. *Pleurotoma alticincta* Marshall and Murdoch, another of out most elegant shells, and some undescribed species, possess the same peculiar apex and style of shell and are referable to this genus, which may be placed in the Neptuneidae (= Chrysodomidae Cossmann) till a better location is found.

Genus Austrofusus Kobelt, 1879.

Iredale and Finlay (MS.) show that this comes into use *vice Aethocola* Iredale, and that the Recent species takes the name *Austrofusus glans* (Bolten, 1798).

Under the name *Siphonalia* Suter has included in his various lists of fossil shells several diverse types. These can be roughly separated into two groups—the Verconellids and the Austrofusids. The typical form of *Austrofusus* has somewhat the appearance of a spiny *Verconella* with a short canal, but the presence of an anterior notch at once removes it to the Buccinidae; in fact, the line of separation between some forms of *Austrofusus* and *Cominella* is slight. *Austrofusus*, however, has a "tail," on which the fasciole and notch are placed, while in *Cominella* these seem to cut into the body of the shell itself. But perhaps the best and most important distinguishing feature of *Austrofusus* is the protoconch. This is always conic, polygyrate, and sharply pointed, of 3 or 4 smooth whorls, followed by ½–¾ whorl with brephic sculpture of curved backwardly-sloping axial riblets, twice their width apart; while *Cominella* has a pauci-spiral, globose, slightly asymmetrical embryo, with but little distinct brephic sculpture. This difference in the two genera is constant and very marked, and is exactly comparable to a difference between two groups of the Mitridae, *Austrofusus* having almost the apex of *Mitra* s. str., while *Cominella* imitates *Vexillum*.

The species at present referable to *Austrofusus* may be divided into groups by considering the development of the canal and the siphonal fasciole. *Nassicola* Finlay has been proposed for one well-marked group (*Trans. N.Z. Inst.*, vol. 55, p. 514, 1924), as typified by *Neptunea costata* Hutton. *Aethocola beta* n. sp. (described below) may be put forward as type of another distinct section, for which I propose the new name *Neocola*. Finally, a peculiar development is represented by *Neptunea subnodosa* Hutton and its allies, and for these I constitute a new genus *Zelandiella*, with that species as type. The classification thus becomes—

Genus *Austrofusus* Kobelt, Type, *Neptunea nodosa* Martyn (= *Drupa glans* Bolten).
  Section *Austrofusus* s. str.
  Section *Neocola* nov. Type, *Austrofusus beta* n. sp.
  Section *Nassicola* Finlay. Type, *Neptunea costata* Hutton.
New genus *Zelandiella*. Type, *Neptunea subnodosa* Hutt.

Several other sections are separable, but these will serve at present for the species dealt with in this paper. The chief characters of these groups are as follows :—

Austrofusus.—Includes *glans* (Bolten), *spinifera* (Finlay), *pagoda* (Finlay),* *acuticostata* (Sut.), *affiliata* n. sp., *precursor* n. sp., *tatae* Marwick (*Trans. N.Z. Inst.*, vol. 55, p. 197, 1924), and two new Recent species I am describing later. Characterized by slight development of the fasciole, which is not keeled ; the columellar area is excavated at its join with the parietal wall and considerably twisted lower down, but less suddenly and more regularly than in the other groups. This excavation makes the pillar slightly oblique, and gives the shell a *Verconella*-like aperture.

Neocola.—Includes *flexuosa* (Marshall), *alpha* n. sp., *beta* n. sp., *gamma* n. sp., *apudalpha* n. sp., and many other species not treated of here. Agrees with *Austrofusus* s. str. in having a moderately long canal, downwardly produced after the twist, but the shell is smaller and more solid, with usually a narrowed and contracted aperture, due to the thick outer lip and columella and absence of excavation in the latter. The pillar is relatively less twisted, but often appears more so owing to the greater prominence of the fasciole, which has a marginal carina, sometimes very high and sharp.

Nassicola.—Includes *costata* (Hutt.), *nassa* n. sp., *contracta* n. sp., and *magnifica* n. sp. In shape and appearance of canal this distinct group is somewhat intermediate between *Austrofusus* proper and *Cominella*, but the apex shows that relationship is really with the former. The short and rather indistinct canal is bent well to the left, due to the very strong twist of the columella (in *Austrofusus* s. str. the pillar is much less twisted, and thence continues with a rotatory motion downwards rather than laterally). Notch almost as in *Cominella* (but less penetrating), deeper and narrower than in the typical group ; fasciole strong, keeled.

Zelandiella.—Includes *subnodosa* (Hutt.), *propenodosa* (Bartrum) (with which I would unite *kaawaensis* Bartrum), and *fatua* n. sp. The apex of the type is aberrant, not high and conical, but compressed vertically, like the shell itself, into a mamillary appearance; 3 smooth, tiny, very convex whorls, followed by ½ whorl with axial riblets. The growth of the shell and of the anterior notch, the style of sculpture, and the heavy deposit of callus round the inner lip are all abnormal.

Austrofusus (Neocola) alpha n. sp. (Plate 57, figs. 1–4.)

Moderate size, buccíniform, fairly solid. Embryo conic, polygyrate, sharply pointed, of 3–4 smooth whorls followed by ¾ whorl with brephic sculpture of curved backwardly-sloping axial riblets, twice their width apart. Adult whorls 6, with a medial keel, nowhere very sharp, but weaker on the first and penultimate whorls, tending to obsolescence on body-whorl ; base with no indications of second keel. 11–13 axial ribs per whorl, continuous between sutures on first three whorls, thence obsolete on shoulder and (except on keel, where they remain as blunt swellings) almost vanishing on body-whorl and base ; a little more than own width apart. Spirals appearing as raised cords of regular strength over whole surface, not more prominent on base (though sometimes slightly alternating) ; 11 on penultimate whorl (excluding occasional interstitials), 6 being on shoulder,

* New name proposed in *Proc. Mal. Soc.*, vol. 16, pt. 2, p. 103, for *Siphonalia turrita* Suter, preoccupied.

about 26 on body-whorl and base; the three on keel slightly stronger. Base rapidly contracted into a short and strongly twisted prolongation, containing the fasciole, which is very prominent and bordered by a high sharp carination. Aperture narrow, rapidly contracted to a short deep canal, notched backward but hardly upwards; outer lip grooved at spirals and with short linear ribs farther within. Columella stout, strongly twisted and attenuated low down. Parietal and inner-lip callus well marked but not strong.

Height, 27 mm.; diameter, 15 mm.

Locality.—Clifden, Southland, band 4B (Ototaran ?), also from band 3; common.

Type in Finlay collection.

Distinguished by regular strong spiral sculpture, rounded base, and low nodules. This and the two following species are not much like any other form I have seen; perhaps nearest *A. flexuosa* (Marshall), but that species has a longer canal and shows decided geronticism in its sculpture, whereas these Clifden species all appear hale and vigorous.

Austrofusus (Neocola) beta n. sp. (Plate 57, figs. 5, 6.)

A direct descendant of *A. alpha*, occurring in the next set of beds at the same locality. Distinguished from its predecessor by a tendency to stronger tuberculation, giving the peripheral keel a more angular aspect and the whole shell a broader outline; the spirals are less raised and have lost their regularity, three or four on the base becoming stronger and more prominent, and indicating a low second keel, while the three on upper keel are closer but hardly stronger than the others. Spire-whorls often slightly shorter than in previous species, with keel a little below middle.

Height, 30 mm.; diameter, 17 mm.

Locality.—Clifden, Southland, bands 6A (type) and 6B (Ototaran ?); very common. Also from Pourakino, Riverton.

Type in Finlay collection.

Austrofusus (Neocola) gamma n. sp. (Plate 57, figs. 7, 8.)

Represents the culmination, at this locality, of the *alpha-beta* line. The tendency towards prickly sculpture, manifest on the middle whorls of the two preceding species, has here continued even during the formation of the body-whorl, which bears on the peripheral keel a row of rather sharp serrations, especially prickly on all spire-whorls. Irregularity in spiral sculpture has also much increased, three of the basal cords being very swollen, giving the body-whorl almost a subquadrilateral outline; these cords are also rendered distinctly prickly by the axial ribs. Upper keel marked by a very strong cord.

Height, 23 mm.; diameter, 15 mm. (type). Height, 26 mm.; diameter, 15 mm. (paratype).

Locality.—Clifden, Southland, band 6C (Ototaran ?); common.

Type in Finlay collection.

A few specimens from the same locality but in still higher beds (7A and 7B) seem also referable to this form, but have slightly thinner spirals, and are mostly about twice the size of the typical forms from 6C. I hesitate to erect a further species on the slight amount of poor material available; the differences seen may well be inconstant.

Austrofusus (Neocola) apudalpha n. sp. (Plate 57, figs. 9, 10.)

Shell of the same general build as the preceding forms, but with rather longer canal, more compressed body-whorl, and weaker fasciole. Apex typical, adult whorls 6, medially bluntly keeled. 11–12 axial ribs per whorl, very similar in development to those of *A. alpha*, but higher and more persistent on body-whorl, often extending half-way over base and shoulder. A second keel indicated a little way below first, much nearer to it than in the Clifden shells; below this the base rapidly contracts. Spirals prominent and cord-like, almost equal and equidistant over shoulder and keels, but a trifle stronger and wider apart on base, with one interstitial riblet; practically similar in number and arrangement to those of *A. alpha*. Aperture small but not compressed, outer lip thickened, and with many short linear ridges within. Pillar straight, strongly twisted below, forming a fairly long canal, bent to the left and not deeply notched. Fasciole strong, but not prominently keeled.

Height, 25 mm. (estimated); diameter, 16 mm. (type). Height, 32 mm.; diameter, 19 mm. (figured paratype, Blue Cliffs).

Locality.—Otiake, sandy beds above the limestone (Awamoan) (type); also Blue Cliffs; common.

Type in Finlay collection.

This species has a weaker fasciole and carina, and longer snout, than the typical forms, and it, together with related species, may later prove separable from *Neocola*.

Austrofusus (Nassicola) nassa n. sp. (Plate 56, figs. 8, 9.)

Shell rather small, Cominelliform, fairly solid. Apex typical, 6 adult whorls, bluntly keeled above the middle, shoulder concave, remainder of whorl vertical, base rather convex. On body-whorl a second keel is very faintly indicated but is masked by inflation of base. 13–14 axial ribs per whorl, extending over early whorls, but stopping just above keel from antepenultimate whorl onwards; continuing half-way over base on body-whorl; raised into blunt swellings on keel, especially on last whorl. 10–12 spirals on penultimate whorl, 25–30 on body-whorl, low, flattish, and often grouped in pairs or triplets, with linear interstices, so that space below keel on body-whorl appears to be cut up by about 10 distant grooves. Aperture not contracted, rather wide near canal, which is short, rather indefinite, and strongly notched upwards and to left. Outer lip crenulated by the grooves and, in thickened examples, with many internal lirae. Pillar straight, sharply bent to left low down. Fasciole strong, with a sharp but not high carina. In common with many other species of the genus, the shell has a slight Stromboid notch in outer lip close to canal, shown by growth-lines when lip is imperfect.

Height, 25 mm.; diameter, 14 mm.

Locality.—Clifden, Southland, band 6A (Ototaran ?); several shells.

Type in Finlay collection.

Distinguished from the following species chiefly by more numerous and therefore closer axial ribs (which must be counted on corresponding whorls of adult shells, as they increase slightly in number on earlier whorls), less prominent nodulation on keel, more or less distinct double or triple grouping of spirals, and greater inflation of base.

Austrofusus (Nassicola) contractus n. sp. (Plate 56, figs. 10, 11.)

This species apparently grows to a larger size than its progenitor, quite small examples of which are often found with a thickened and lirate outer lip; other differences already noted. It forms a link between it and *A. costatus* (Hutton), being of about the same size, with similar very lowly convex base (and with stronger indication of a second keel than in *A. nassa*). There is hardly any appearance of grouping of spirals, which are less raised and closer than in *A. costatus*. Both *contractus* and *nassa* have a relatively higher more exsert spire, a more concave shoulder, and a higher peripheral keel than *A. costatus*, the carina of this species being usually below middle of whorls. The Clifden species are, however, almost certainly directly ancestral to Hutton's shell, an example of which (from Target Gully) is here figured for comparison (Plate 56, fig. 12). Hutton's figure of the type (from Mount Harris) (*Trans. N.Z. Inst.*, vol. 9, pl. 16, fig. 2, 1876) is poor, the aperture being too much contracted, and the canal too long, straight, and distinct.

Height, 26 mm.; diameter, 15 mm. (type). Height, 34 mm.; diameter, 19·5 mm. (figured paratype).

Locality. — Clifden, Southland, band 7 (Hutchinsonian); several specimens.

Type in Finlay collection.

Austrofusus (Nassicola) magnificus n. sp. (Plate 57, figs. 11, 12.)

Shell large, spinose, pagodiform. Apex and early whorls much worn. Six whorls remain (probably 2–3 and the embryo are lost), with a strong not high medial carina, studded with sharp high and thick spines on all whorls but especially on the last, 10, 11, and 12 on body-whorl and next two whorls respectively. Spines vertically compressed, somewhat truncated in front and with a medial ridge behind, generally directed a little backwards, and about twice their thickness apart. Emerging from suture is a second keel, prominent, but lower than upper one, also bearing sharp nodules, but these are much lower and less spiny than the others, almost obsolete on last half of body-whorl, usually just visible at suture on spire-whorls, and strongly undulating the suture. Spines connected on all whorls but last by very low thickish axial ribs, extending neither above nor below them; interspaces about twice their width and distinctly sunken. Dense and fine spirals cover whole surface, especially on shoulder; they are of uneven strength and finely wavy; on base the finer threads are very indistinct, but some 16–18 spirals are rather wider and more conspicuous; all, however, are hardly raised above surface; an intermittent strong cord traverses centre of spines on both keels. Growth-lines prominent but not raised, dense and fine; retrocurrent from suture and forming a deep narrow sinus on the spines. Spire about equal in height to aperture, staged. Aperture pyriform, rather ample for the genus; outer lip almost regularly curved, not much thickened, feebly multilirate within. A posterior channel and slight vertical sinus above. Parietal wall smooth, not excavated. Columella straight, much twisted far down to form with outer lip a short deep and rather indistinct canal, strongly flexed to left and with a deep narrow notch tending upwards and laterally. Fasciole rather narrow, raised and prominent, margined by a low but sharp carina.

Height, 55 mm.; diameter, 36 mm.

Locality.—Clifden, Southland, band 6C (Ototaran ?); one specimen. Also a spire fragment from band 7B (Hutchinsonian).

Type in Finlay collection.

Apparently not closely related to any other species of the genus, though evidently referable to the "*costatus*" group. Style of sculpture very reminiscent of *Struthiolaria spinosa* Hector.

Zelandiella fatua n. sp. (Plate 58, figs. 17, 18.)

Shell like a *Sycum* in shape, tumid, rather solid, heavily calloused over columella area. Apex and early whorls much rubbed, but probably about 6 adult whorls of growth. Whorls rounded, without carinae; a slight depression below suture and another weaker one on base, giving the impression of a sutural swelling and a peripheral tumidity. Traces of weak and blunt axial ribs (15–16 per whorl) remain on the eroded early whorls, but last two whorls seem to have had no axial sculpture. Spirals prominent, distant, cord-like, quite thin, 2–5 times their width apart, but appearing rather uniformly distributed, 4–5 on penultimate, 20 on body whorl. Towards aperture body-whorl is pushed away from penultimate by callus-deposit that begins to form interiorly at suture. During the last quarter-whorl this deposit quickly increases in bulk and ends in a huge callus-pad, filling up posterior part of aperture, leaving only a linear posterior channel and vertical groove. The callus spreads rather thinly far over parietal wall and half-way up penultimate, then, a little below periphery, extends on to base in a thick lip as in *Struthiolaria;* this is suddenly followed anteriorly by a wide regularly concave channel, over which and most of fasciole the callus is just thick enough to smooth out all details of ornament. Outer lip a little thickened, undulating, and rather expanded, very faintly lirate within. Aperture ample, almost subquadrilateral, rapidly contracted below into a distinct short and deep canal, bent to the left but directed more downwards, deeply and almost laterally notched at base. Fasciole wide and strong, though mostly effaced by callus, bounded by a sharp and high keel, and with a much weaker median sub-keel.

Height, 32 mm.; diameter, 21 mm.

Locality.—Lower Waipara sandy beds (Tongaporutuan ?); three shells.

A very curious-looking shell, undoubtedly congeneric with Hutton's *Cominella subnodosa*, but well distinguished from it by absence of keels and bolder spiral sculpture. Gerontic characters already indicated in that species have here fully developed. Included by Speight in a list of fossils from Lower Waipara (*Trans. N.Z. Inst.*, vol. 44, p. 231, 1912) as "*Galeodea* sp. Small variety, probably distinct."

Austrofusus (s. str.) precursor n. sp. (Plate 58, figs. 15, 16.)

This and the following species are so generally similar to *A. spinigera* (Finlay) and the Recent *A. glans* (Bolten), and so evidently the direct ancestors of those species, that they are best described by comparison with them. The apex in all is typical, and all have about 14 axial ribs per whorl. The three Tertiary species differ from *A. glans* in having the axial ribs continuous between the two rows of nodules, which are vertically compressed and rather wedge-shaped; in the Recent shell the ribs are almost obsolete, and the nodules are pointed and appear more spiny. The fossil shells also have a longer and more twisted canal, with a shallower

notch. The present species has very unequal spiral sculpture; a rather strong cord margins suture, weak spirals cover the shoulder, a strong cord on upper keel with another close above it (the two most conspicuous spirals on spire-whorls), uneven spirals between the keels, a group of three strong cords on lower keel, three massive raised cords on base (with wide interstices crossed by fine spiral threads, centre one slightly stronger), alternating strong and weak cords over remainder of base and canal. Nodules on upper keel are directed slightly upwards, and this effect is enhanced by the slight concavity of shoulder. *A. spinigera* and *A. glans* have much less conspicuous and more equal spiral ornament, no sutural band, no stronger peripheral or supra-peripheral cords, and but weakly developed stronger ribs on base (interstitial ribs mostly obsolete, what remain being little inferior to main ribs); the nodules are directed more outwards and the shoulder is more sloping and straight.

Height, 35 mm.; diameter, 20 mm. (type). Height, 30 mm.; diameter, 17 mm. (paratype).

Locality.—Chatton sands, Southland (Ototaran ?); two specimens. Also Wharekuri greensands.

Type in Finlay collection.

Austrofusus (s. str.) affiliatus n. sp. (Plate 58, figs. 12–14.)

Related to previous species by its sutural cord, two stronger peripheral cords, and strong basal spirals (which, however, are more evenly placed and graded), but differing in having a straight shoulder and outwardly (not upwardly) pointing nodules. This is due mostly to extension of axial ribs almost to sutures in this species, whereas in *A. precursor* they cease shortly above keel. The figures, however, show the slight differences between the two species better than any verbal description. Fig. 12 depicts a specimen attaining senility, which is shown (as in the Recent species) by rounding of body-whorl, loss of nodules, and crowding of variceal growth-lines. The adult size of the Tertiary shell is thus considerably less than that of *A. glans*.

Height, 30 mm.; diameter 15·5 mm (type). Height, 34 mm.; diameter, 16 mm .(senile paratype).

Locality.—Otiake, sandy beds above the limestone (Awamoan); several specimens.

Type in Finlay collection.

Genus Cominella Gray, 1850.

Since Iredale's "Commentary" was published the radular characters of this group have been studied by Cooke. In New Zealand three or four groups have developed, and their relationships are not well known. In Australia the "*costata*" group is associated with the "*lineolata*" group so closely that some workers have even suggested that they are conspecific. The latter has been stated to represent the "*maculosa*" series, but the relationship may not be as close as at first sight seems apparent.

The diminutive used by Gray is suggestive of an altered nomination, and this is found to be the case, for in the *Ann. Mag. Nat. Hist.*, ser. 2, vol. 13, 1853, p. 420, Gray quotes *Cominia maculata* instead of *Cominella maculata*, thus suggesting that his original name was *Cominia*, and that he

amended it to *Cominella* on account of his recalling the prior *Cominia* of Brown.*

All the New Zealand species, which at first sight seem difficult to divide into groups, may be separated into two major divisions—the *nassoides-quoyana* association, and the remainder. Despite all the variation in shape, size, and general appearance in both groups, there are two characters which are found in the former and always serve to mark its members off from those of the latter; these are (1) a large swollen embryo, flatly dome-shaped on top, with no succeeding stage of axial acceleration, and (2) the possession of a *Phos*-like ridge or plait at the base of the columella, distinctly raised in one section of the group, indicated by a more or less deep groove in the others. The latter character is better marked and usually more serviceable than the former: the possession of these factors indicates the relationship between *quoyana* and its congeners and *nassoides* with its relatives. Gray's original root name *Cominia* may be continued by the formation of diminutives and derivatives to cover the associations which are here outlined. The discernable groups in the first division are—

Eucominia n. gen. Type: *Buccinum nassoides* Reeve.

This will also include the "Miocene" *C. intermedia* Suter (*N.Z. Geol. Surv. Pal. Bull.* 5, p. 33, 1917) and the Pliocene new species *E. excoriata* Finlay, *E. elegantula* Finlay, and *E. nana* Finlay (*vide infra*). The Chatham Island Recent form of *nassoides* (Hutton's "var. B") is regionally distinct from the mainland shell, while a directly ancestral new species occurs there fossil. These are all moderately large shells, with characteristic spiral sculpture of very dense microscopic grooves, over which may appear a further ornament of very low cords with wider interstices; the axial sculpture frequently tends to become nodulous on the shoulder and below the suture. The Palaeocene *C. sublurida* Marshall (*Trans. N.Z. Inst.*, vol. 49, p. 455, 1917) seems to belong to this group, which thus shows considerable antiquity.

Cominula n. gen. Type: *Cominella quoyana* A. Adams.

A group of small shells with heavy axial sculpture, persistent over body-whorl and base, large embryo and columellar groove as in *Eucominia*, but with rather weak spiral sculpture of fine cords. Here will be referred the Pliocene *Clathurella hamiltoni* Hutton (*Trans. N.Z. Inst.* vol. 17, p. 316, 1885; also Marwick, *Trans. N.Z. Inst.*, vol. 55, p. 197, 1924) and several new Pliocene species. A group of shells from the "Miocene"—*pulchra* Suter, *exculpta* Suter, *denselirata* Finlay, *propinqua* Finlay, *praecox* Finlay, and *pukeuriensis* Finlay (*vide infra*), and probably *compacta* Marwick (this volume, p. 322)—may be separated subgenerically as *Procominula* nov., with the first-named as type; in these forms the axial ribs become nodulous on the keel, which is near the lower instead of the upper suture, and the canal is rather longer.

Zephos n. gen. Type: *Nassa cingulata* Hutton.

Moderately small shells with large embryos, strong axial ribs, and thick prominent spiral cords; the basal columellar plait is very strong, much as

* I have to thank Mr. Tom Iredale for nomenclatural assistance in this case and that of *Cominella lurida* (Phil.), discussed below.

in true *Phos*. With the Pliocene type (*Trans. N.Z. Inst.*, vol. 17, p. 327, 1884) must be associated two other Pliocene forms, *Clathurella incisa* Hutton and *Cominella purchasi* Suter. A Recent representative may be the shell Suter identified as *Phos tenuicostatus* (Ten.-Woods), a record that should be rejected. Suter's specimens are not available, but a shell believed to be the same species occurs off Otago Heads in 60 fathoms and proves to be quite distinct from the Tasmanian shell. Tate and May have commented on the affinities of *Cominella tenuicostata* Ten.-Woods with some Australian Tertiary species (*Proc. Linn. Soc. N.S.W.*, vol. 26, p. 454, 1901), such as *Phos cominelloides* Tate, and for these Iredale (*Rec. Austr. Mus.*, vol. 14, p. 262, 1925) has provided the genus *Fax*, with *Phostabidus* Hedley as type: the New Zealand Recent shell may prove to belong here rather than to *Zephos*.

The second division of the Neozelanic "*Cominella*" may also be subdivided into groups, of which the "*lurida*" and *adspersa* associations are the chief.

Cominista n. gen. Type: *Buccinum glandiforme* Reeve, 1847 (= *Buccinum luridum* Philippi, 1848).

This name-alteration of the type species is rather curious, as the latter name is omitted by Suter, yet it is recorded in the early accounts of Neozelanic Mollusca. The correction was independently noted in the British Museum by Iredale and Tomlin, the former naming Neozelanic Mollusca, the latter determining South African forms, among which Reeve's species had been recently incorrectly placed.

C. chattonensis Finlay and *C. obsoleta* Finlay (*vide infra*) are members of this group, which may in the meantime also contain the Australian *C. eburnea* Reeve, though the radulae differ a little. The vertically spirally recurved columella, the strong shoulder, and the nodular axial sculpture chiefly distinguish this genus.

Acominia n. gen. Type: *Buccinum adspersum* Bruguière.

This species and its ancestors *C. hendersoni* Marwick (this volume, p. 322), *C. carinata* Hutton (*Cat. Tert. Moll.*, p. 6, 1873), and *C. ridicula* Finlay (*vide infra*) show a tendency to develop a crass almost quadrilateral shell with vertical whorl sides. Axial sculpture, of close rather swollen ribs, early becomes obsolete; the pillar is strongly and abruptly twisted, the anterior notch very deep. Near this group may be placed the two remaining Recent species, *maculosa* and *virgata*, and perhaps, as a relative of the last, *C. accuminata* [*sic*] Hutton (*Mac. Mem. Vol., Plioc. Moll.*, p. 43, 1893). These are aberrant forms, but at the present time their lineage is not known, and one may therefore hesitate to discuss their true affinities. *C. maculosa* itself, under the synonymic name *testudinea*, has been designated as type of *Cominella* Gray (Iredale, *Proc. Mal. Soc.*, vol. 13, p. 34, 1918), which, in a strict sense, should therefore be used only for these three forms.

Eucominia elegantula n. sp. (Plate 57, figs. 14, 15.)

Shell of medium size, smooth except for dense spirals and subobsolete axials, with large embryo and columellar groove. Apex large and bulbous, of three smooth globose whorls, dome-shaped on top, decidedly asymmetrical. 16–17 weak axial ribs per whorl (interstices shallow and wider), slightly

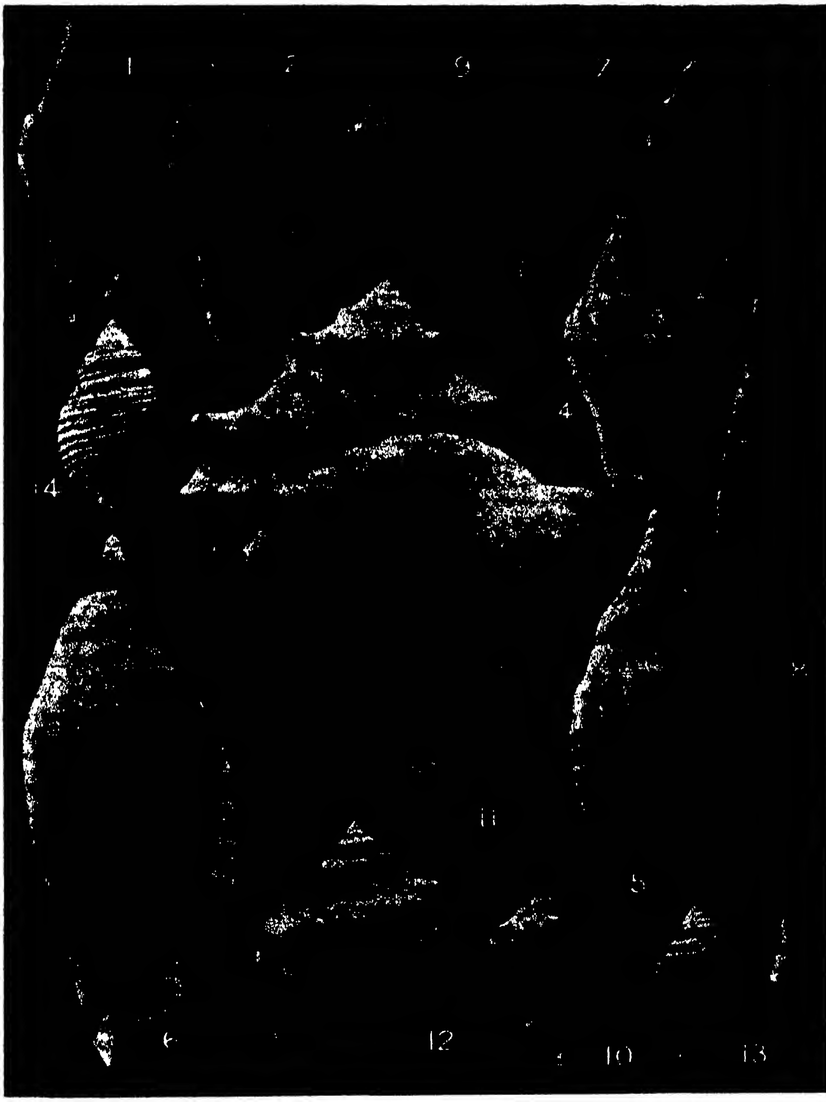


FIG. 1.—*Miomelon clifdenensis* n. sp.: holotype. × 1.
FIG. 2.—*Miomelon clifdenensis* n. sp.: paratype. × 1.
FIG. 3.—*Miomelon clifdenensis* n. sp.: paratype (band 6c). × 1.
FIG. 4.—*Alcithoe regularis* n. sp.: holotype. × 1.
FIG. 5.—*Alcithoe residua* n. sp.: holotype. × $\frac{1}{2}$.
FIG. 6.—*Miomelon benitens* n. sp.: holotype. × $\frac{3}{4}$.
FIG. 7.—*Scaphella pretiosa* n. sp.: paratype. × 1.
FIG. 8.—*Scaphella pretiosa* n. sp.: holotype. × 1.
FIG. 9.—*Alcithoe dyscrita* n. sp.: holotype. × 1.
FIG. 10.—*Euspinacassis pollens* n. sp.: juvenile paratype. × 1.
FIG. 11.—*Euspinacassis pollens* n. sp.: holotype. × 1.
FIG. 12.—*Euspinacassis pollens* n. sp.: half-grown paratype. × 1.
FIG. 13.—*Austrotoma obsoleta* n. sp.: holotype. × 1.
FIG. 14.—*Austrotoma obsoleta* n. sp.: paratype. × 1.

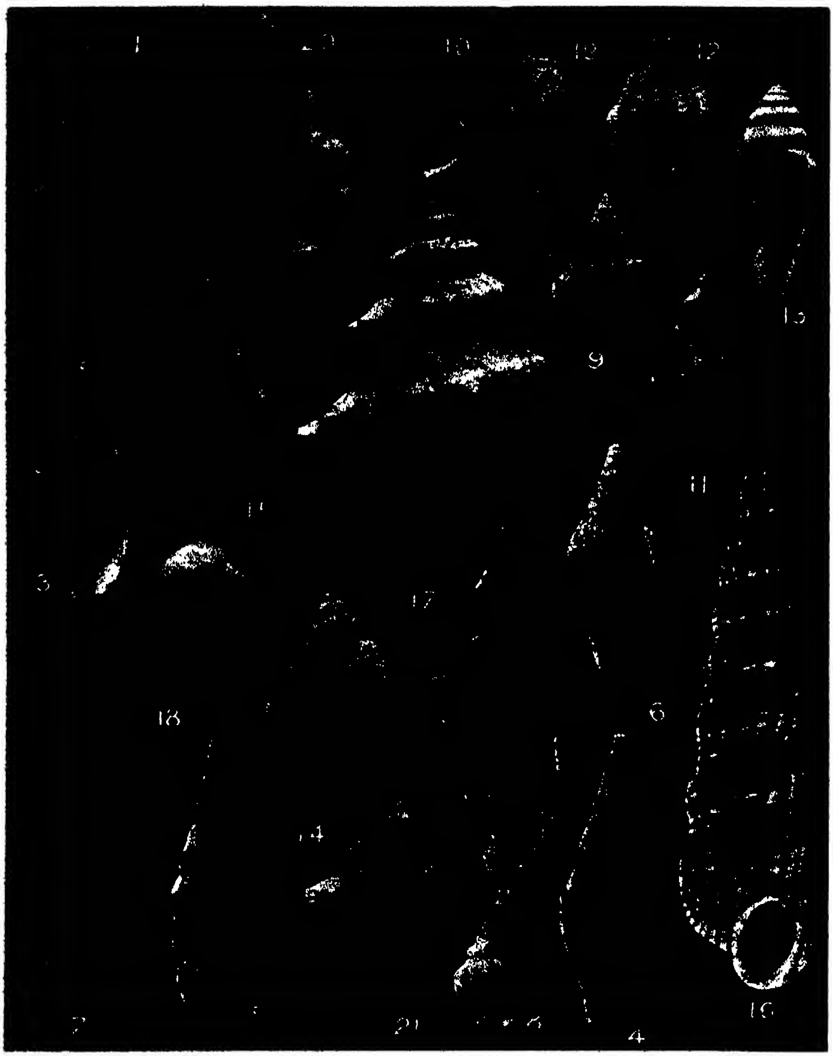


FIG. 1.—*Alcithoe phymatias* n. sp. : holotype. × 1.
FIGS. 2, 3.—*Alcithoe phymatias* n. sp. : paratypes. × 1.
FIG. 4.—*Alcithoe bathgatei* n. sp. : holotype. × 1.
FIG. 5.—*Alcithoe bathgatei* n. sp : paratype (band 6A). × 1.
FIG. 6.—*Scaphella tumidior* n. sp. : holotype. × 1.
FIG. 7.—*Scaphella cognata* n. sp. : holotype. × 1.
FIG. 8.—*Austrofusus (Nassicola) nassa* n. sp. : paratype. × 1.
FIG. 9.—*Austrofusus (Nassicola) nassa* n. sp. : holotype. × 1.
FIG. 10.—*Austrofusus (Nassicola) contractus* n. sp. : holotype. × 1.
FIG. 11.—*Austrofusus (Nassicola) contractus* n. sp. : paratype. × 1.
FIG. 12.—*Austrofusus (Nassicola) costatus* (Hutton) : Target Gully specimen. × 1.
FIG. 13.—*Conospira rivertonensis* n. sp. : holotype. × 1.
FIGS. 14, 15.—*Aphera (?) scopalveus* n. sp. : holotype. × 2.
FIG. 16.—*Notacirsa oamarutica* (Suter) : topotype. × 10.
FIG. 17.—*Struthiolaria prior* n. sp. : holotype. × 1.
FIG. 18.—*Baryspira waikaiensis* n. sp. : holotype. × 1.
FIG. 19.—*Baryspira waikaiensis* n. sp. : paratype. × 1.
FIG. 20.—*Vesanula chaskanon* n. sp. : holotype. × 2.
FIG. 21.—*Vesanula chaskanon* n. sp. : paratype. × 2.

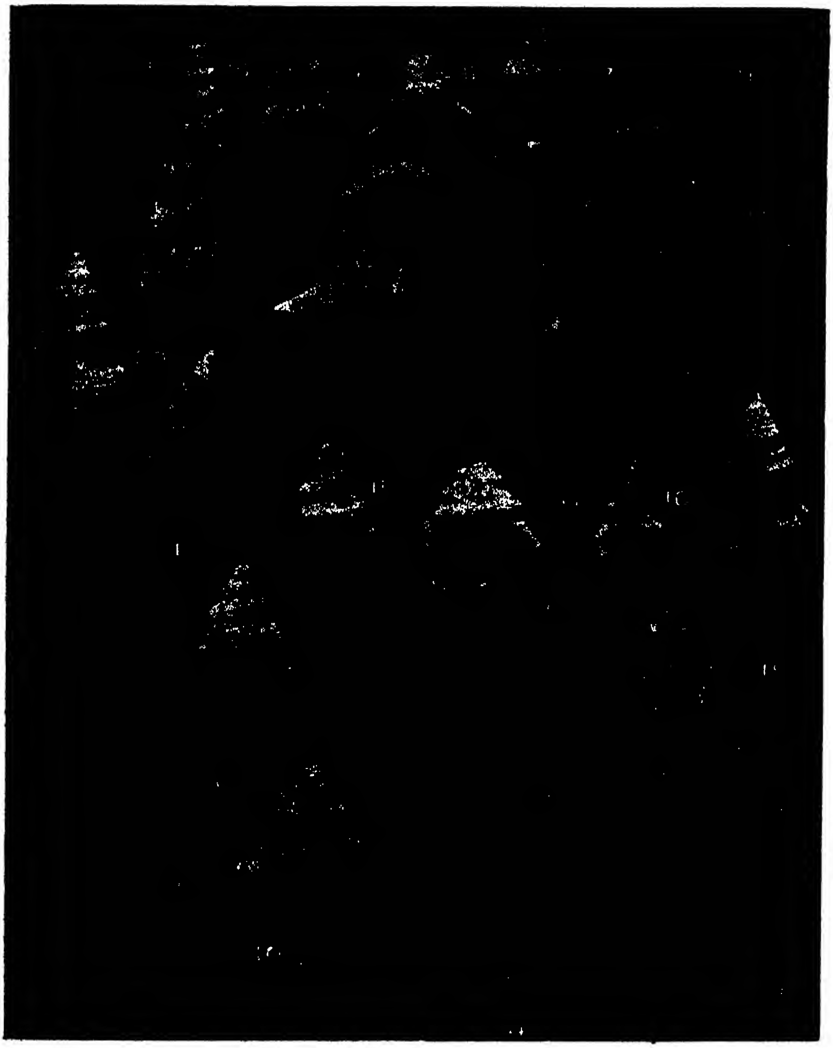
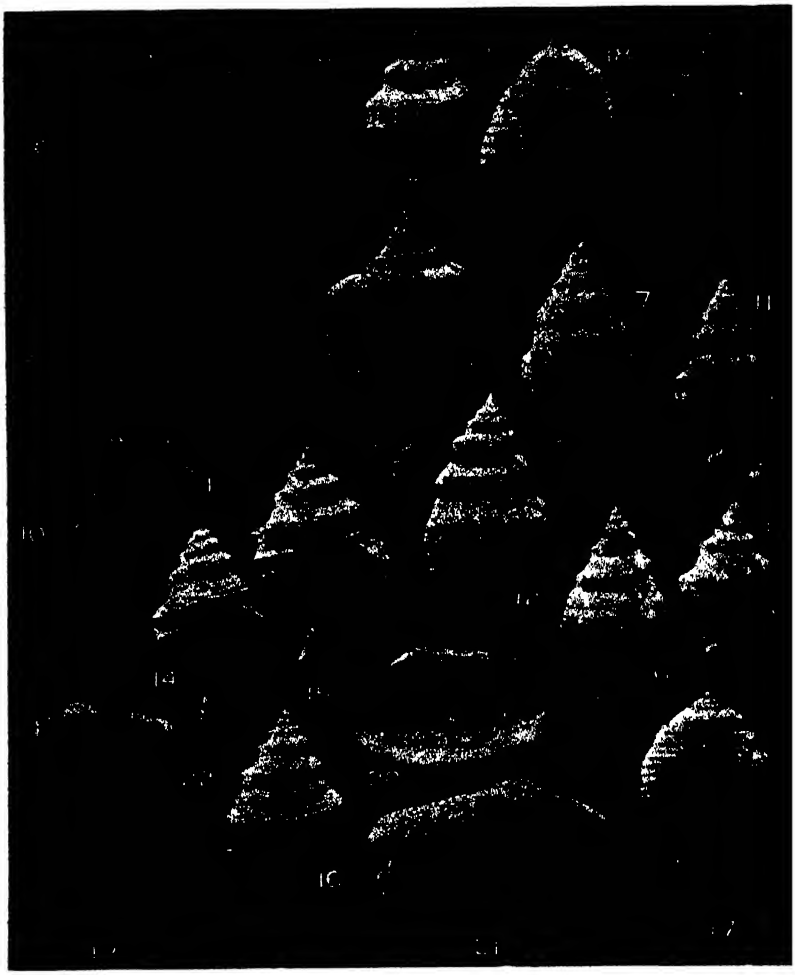
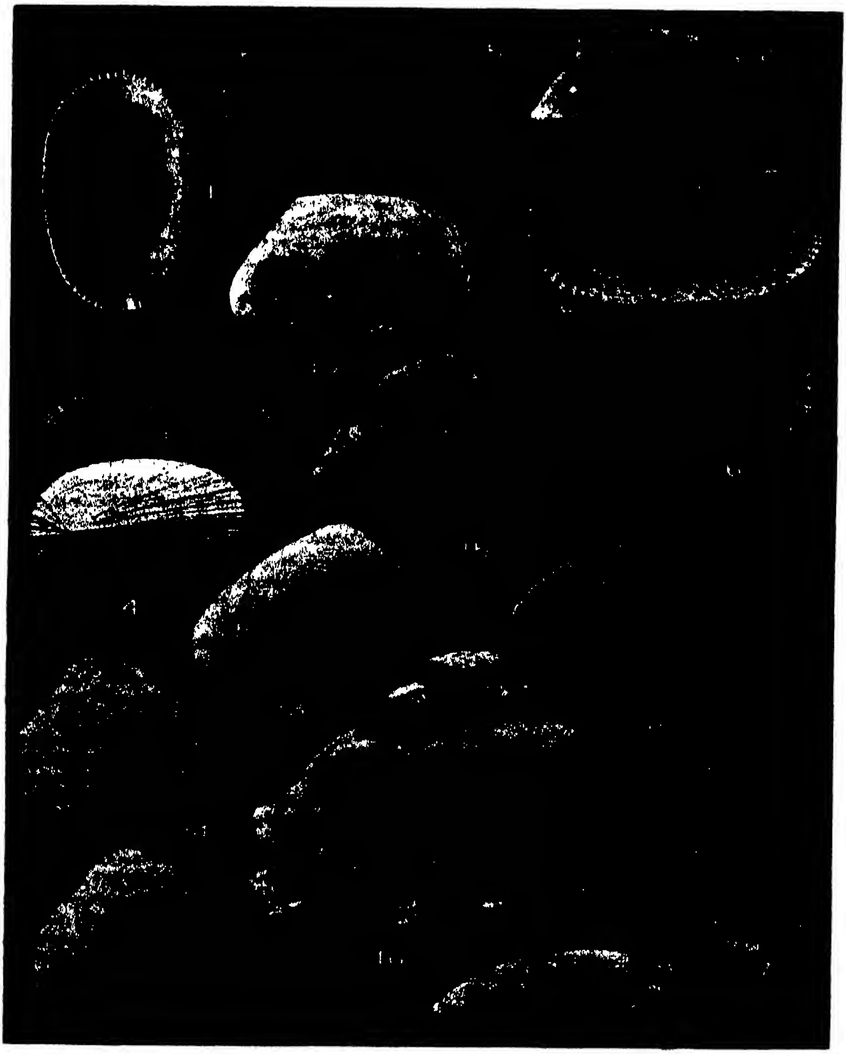


Fig. 1.—***Austrofusus (Neocola) alpha*** n. sp.: paratype (band 3). × 1.
Figs. 2, 3.—***Austrofusus (Neocola) alpha*** n. sp.: holotype. Fig. 2, × 1; fig. 3, × 2.
Fig. 4.—***Austrofusus (Neocola) alpha*** n. sp.: apex of holotype. × 10.
Fig. —***Austrofusus (Neocola) beta*** n. sp.: paratype. × 1.
Fig. —***Austrofusus (Neocola) beta*** n. sp.: holotype. × 1.
Fig. —***Austrofusus (Neocola) gamma*** n. sp.: holotype. × 1.
Fig. —***Austrofusus (Neocola) gamma*** n. sp.: paratype. × 1.
Fig. —***Austrofusus (Neocola) apudalpha*** n. sp.: holotype. × 1.
Fig. 10.—***Austrofusus (Neocola) apudalpha*** n. sp.: paratype (Blue Cliffs). × 1.
Figs. 11, 12.—***Austrofusus (Nassicola) magnificus*** n. sp.: holotype. × 1.
Fig. 13.—***Eucominia excoriata*** n. sp.: holotype. × 1.
Fig. 14.—***Eucominia elegantula*** n. sp.: paratype. × 1.
Fig. 15.—***Eucominia elegantula*** n. sp.: holotype. × 1.
Fig. 16.—***Eucominia elegantula verrucosa*** n. subsp.: holotype. × 1.
Figs. 17, 18.—***Cirsostrema caelicola*** n. sp.: holotype. Fig. 17, × 1; fig. 18, × 1½.
Fig. 19.—***Austrotoma scopalveus*** n. sp.: holotype. × 1.
Fig. 20.—***Austrotoma scopalveus*** n. sp.: paratype. × 1.



FIGS. 1, 2.—*Acominia ridicula* n. sp. : holotype. × 1.
FIG. 3.—*Cominista obsoleta* n. sp. : holotype. × 2.
FIG. 4.—*Cominista obsoleta* n. sp. : paratype. × 2.
FIG. 5.—*Cominista chattonensis* n. sp. : holotype. × 1.
FIG. 6.—*Cominista chattonensis* n. sp. : paratype. × 1.
FIG. 7.—*Eucominia nana* n. sp. : holotype. × 2.
FIG. 8.—*Cominula (Procominula) pulchra* (Suter) : topotype. × 2.
FIG. 9.—*Cominula (Procominula) denselirata* n. sp. : holotype. × 2.
FIG. 10.—*Cominula (Procominula) pukeuriensis* n. sp. : paratype. × 2.
FIG. 11.—*Cominula (Procominula) pukeuriensis* n. sp. : holotype. × 2.
FIG. 12.—*Austrofusus* (s. str.) *affiliatus* n. sp. : senile paratype. × 1.
FIG. 13.—*Austrofusus* (s. str.) *affiliatus* n. sp. : paratype. × 1.
FIG. 14.—*Austrofusus* (s. str.) *affiliatus* n. sp. : holotype. × 1.
FIG. 15.—*Austrofusus* (s. str.) *precursor* n. sp. : holotype. × 1.
FIG. 16.—*Austrofusus* (s. str.) *precursor* n. sp. : paratype. × 1.
FIG. 17.—*Zelandiella fatua* n. sp. : holotype. × 1.
FIG. 18.—*Zelandiella fatua* n. sp. paratype. × 1.
FIG. 19.—*Neilo sinangula* n. sp. : holotype. × 1.
FIG. 20.—*Neilo awamoana* n. sp. : paratype (Ardgowan). × 1.
FIG. 21.—*Neilo awamoana* n. sp. : holotype. × 1.
FIG. 22.—*Neilo awamoana* n. sp. paratype (Devil's Bridge). ×



FIGS. 1, 2.—*Tugali pliocenica* n. sp. : holotype. × 2.
FIGS. 3, 4.—*Tugali pliocenica* n. sp. : paratype. × 2.
FIG. 5.—*Tugali pliocenica* n. sp. : senile paratype. × 2.
FIGS. 6, 7.—*Tugali navicula* n. sp. : holotype. × 2.
FIGS. 8, 9.—*Tugali navicula* n. sp. : paratypes. × 2.
FIG. 10.—*Spissatella discrepans* n. sp. : holotype. × 1.
FIG. 11.—*Spissatella poroleda* n. sp. : holotype. × 1.
FIG. 12.—*Spissatella scopalveus concisus* n. subsp. : holotype. × 1.
FIGS. 13, 14.—*Spissatella traillí* (Hutt.) : Mount Harris specimens. × 1.
FIG. 15.—*Onustus prognatus* n. sp. : holotype. × 1.
FIG. 16.—*Onustus prognatus* n. sp. : paratype (Clifden). × 1.

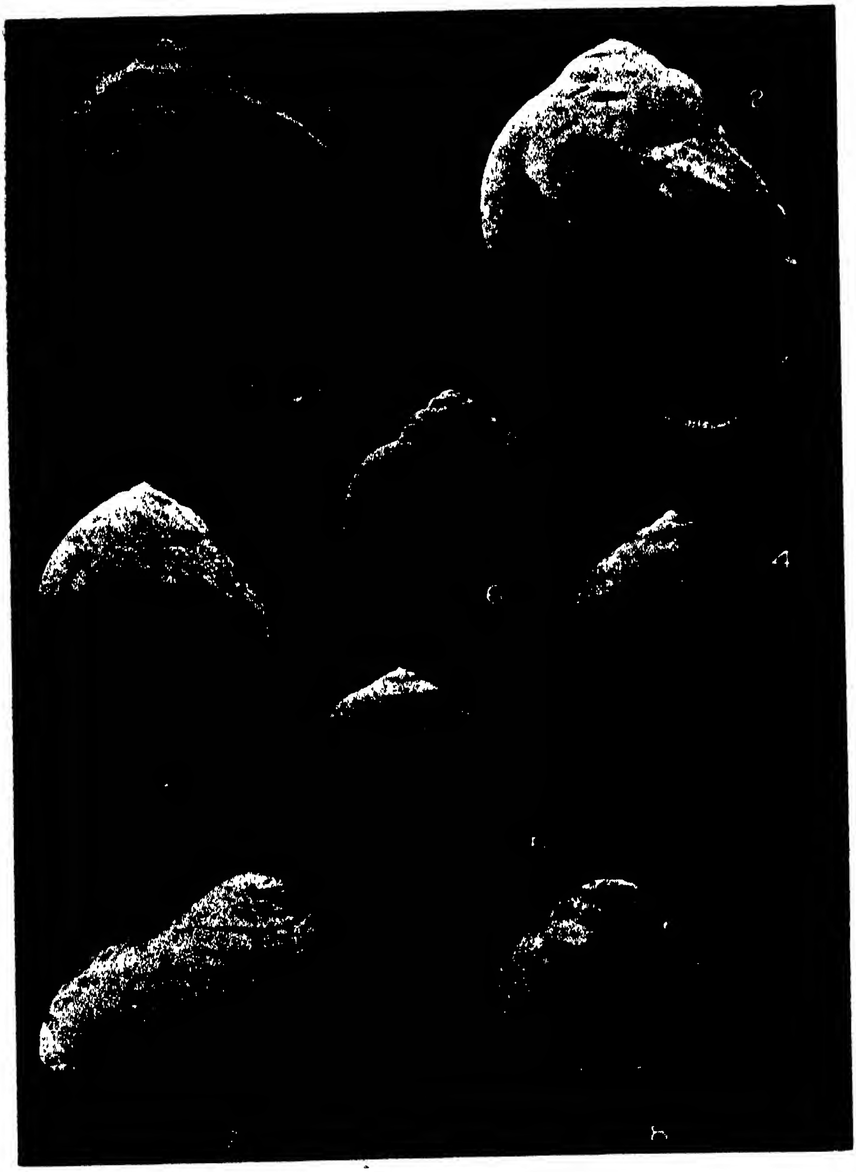


Fig. 1.—*Uber laxus* n. sp.: holotype. × 1½.
Fig. 2.—*Magnatica (Spelaenacca) clifdenensis* n. sp.: holotype. × 1½.
Fig. 3.—*Magnatica (Spelaenacca) altior* n. sp.: holotype. × 1½.
Fig. 4.—*Magantica (Spelaenacca) altior* n. sp.: paratype. × 1½.
Fig. 5.—*Magnatica (Spelaenacca) rectilatera* n. sp.: holotype. × 1½.
Fig. 6.—*Globisinum crassiliratum* n. sp.: holotype. × 2.
Fig. 7.—*Spissatella scopalveus* n. sp.: holotype. × 1.
Fig. 8.—*Spissatella scopalveus* n. sp.: paratype. × 1.

noduling a subsutural ridge, absent on shoulder and obsolete on body-whorl. Very fine dense undulating linear grooves over whole surface, grouped into more or less distinct ribs on base. Spire taller than aperture, outlines straight. Whorls subangled above middle, concave on shoulder, lightly convex below; body-whorl rounded, gradually contracted. Suture distinct, straight. Aperture subpyriform, angled above, open below in wide indistinct canal. Outer lip thin and sharp, with numerous short blunt teeth well inside, a slight subangled sinus at shoulder. Inner lip not raised, but well marked as a thin callus-deposit. Pillar straight, hardly excavated, with a well-marked generic notch, below which it is somewhat raised and twisted to canal. Fasciole strong; base deeply notched.

Height, 31 mm.; diameter, 14 mm.

Locality.—Castlecliff (Castlecliffian); not uncommon.

Type in Finlay collection.

The smooth and graceful appearance, large embryo, and dense microscopic sculpture render this species quite distinct: it seems so far to have been regarded as *C. virgata*, with which it has little in common.

Subspecies verrucosa n. subsp. (Plate 57, fig. 16.)

Differs from the typical form in much stronger development of axial sculpture. Ribs persistent over body-whorl, though disappearing on base, forming two distinct lines of nodules, one on periphery and another on a ridge below suture, a narrow smooth concave space between. This brings the subspecies closer to *nassoides*, from which it differs in less-inflated shell, shape of whorls, and spiral sculpture, which in this is not cord-like. All other details as in the species.

Locality.—Same as last, with the species itself, but rarer.

Type in Finlay collection.

Eucominia excoriata n. sp. (Plate 57, fig. 13.)

Shell close to *elegantula*, of same size and general form. Apex lost but probably large. Differs from *elegantula* in strength of axial sculpture. Eleven strong ribs per whorl, continuous over all spire-whorls, and only a little reduced in strength on shoulder; nodules on periphery and below suture are but very faintly indicated; ribs disappear only near fasciole. Irregular low distinct spiral cords on body-whorl as in *nassoides* Reeve, overlain by the extremely dense sculpture seen in *elegantula*, and characteristic of this group. Pillar with a weak groove. Outer lip not toothed within. Other details as in *elegantula*.

Height, 33 mm.; diameter, 16 mm.

Locality.—Shrimpton's, Poverty Bay district (Nukumaruian); one specimen.

Type in Finlay collection.

The strong sculpture brings this species near *nassoides*, but it has the slender shape of *elegantula*, and no double nodular row.

Eucominia nana n. sp. (Plate 58, fig. 7.)

Shell small, biconic, with nodular axials and many spirals. Apex moderately large, conically dome-shaped, symmetrically coiled. 11–12 axial ribs per whorl, strong on spire-whorls (but much diminished on shoulder), almost reduced to nodules on periphery of body-whorl, quite absent on base;

interstices twice their width. Regular equal low spiral cords over whole surface, about 10 on penultimate whorl, 20 on body-whorl; interstices of same width. Spire equals aperture in height, sides straight. Whorls medially bluntly angular, shoulder concave, faintly convex below; base almost regularly tapering. Suture distinct, the whorls clasping. Aperture subpyriform, sharply and narrowly angled above, open below in a rather long distinct canal, not deeply notched behind. Outer lip thin and sharp, much thickened and with short thin teeth inside. Inner lip distinct, a trifle excavated. Pillar roundly hollowed above, with a faint groove below and apparently a feeble blunt ridge above it.

Height, 15 mm.; diameter, 7·5 mm.

Locality.—Otiake, sandy beds above the limestone (Awamoan); one specimen.

Type in Finlay collection.

Somewhat like *pulchra* in size and appearance, but with weaker shoulder and ribs (which are more numerous), different spirals, and symmetrical apex. Practically a miniature of *E. intermedia* (Suter), agreeing exactly in shape and spiral sculpture, but with more-angled whorls, smaller and more valid axials, and a much smaller test and apex.

Cominula (Procominula) pukeuriensis n. sp. (Plate 58, figs. 10, 11.)

Shell small, with nodular axials and inconspicuous spirals. Apex paucispiral, of two small slightly asymmetrical whorls, sharply marked off. 11–13 narrow sharp axial ribs per whorl, strong on spire-whorls (except on shoulder, where they are generally much weaker), diminished quickly on base of body-whorl, but developing small sharp tubercles on periphery; interstices 2–3 times their width. Spiral sculpture very weak, of many faint irregular threadlets over all whorls (interstices of varying width but generally narrower), three or four stronger distant threads on base. Spire equals aperture in height, sides straight. Whorls medially sharply angled, shoulder wide, slightly concave, straight below. Suture distinct. Aperture as in previous species except that outer lip advancing above periphery and very feeble teeth only occasionally present within. Pillar-groove more distinct, with no ridge above it, and canal much more deeply notched.

Height, 14 mm.; diameter, 6·5 mm.

Locality.—Pukeuri sandy clays (Awamoan); fairly common. Also Target Gully, Awamoa, and Rifle Butts (?) (the single specimen has 15 subnodular axials, but is otherwise similar).

Type in Finlay collection.

Cominula (Procominula) pulchra (Suter). (Plate 58, fig. 8.)

Figured from a Blue Cliffs topotype for comparison with the closely allied species here described. Chiefly characterized by its wide shell, angulate periphery low down on whorls (near lower suture instead of medial or supramedial), fewer axial ribs (9–10), lower spire (generally less than aperture), and strong spiral sculpture, which consists of numerous faint threadlets on shoulder, 3 stronger and distant narrow threads on periphery, centre one marking highest point of axial ribs, and many distinct distant narrow threads below, gradually becoming stronger near canal.

Cominula (Procominula) denselirata n. sp. (Plate 58, fig. 9.)

Shell very similar to *C. pulchra* (Suter), apex being of same style but intermediate in size between those of *pulchra* and *pukeuriensis*.

9–10 axial ribs as in *pulchra*, though less prominent and reduced to tubercles on body-whorl, interstices 2–3 times as wide. Spirals very dense and fine all over, with linear grooves between, not more prominent on periphery or base. Spire a trifle lower than aperture; whorls medially angled. Aperture as in *pukeuriensis*, but lirae inside outer lip longer and stronger.

Height, 14 mm.; diameter, 7 mm.

Locality.—Otiake, sandy beds above limestone.

Type in Finlay collection.

Cominula (Procominula) propinqua n. sp.

Twelve axials per whorl, reduced on body-whorl almost entirely to elongate nodules on periphery, and even on penultimate whorl disappearing before reaching sutures. Spirals as in previous species, but rather more raised and prominent, grooves between not quite linear. Otherwise similar to *denselirata.*

Height (estimated), 18 mm.; diameter, 9 mm.

Locality.—Wharekuri greensands.

Type in Finlay collection.

Cominula (Procominula) exsculpta (Suter).

The unique holotype is generally similar to *pulchra* in style of ornament, and has the same swollen apex, but is considerably more elate (more the shape of *denselirata*). 10 axials per whorl, only slightly weaker on shoulder and strong over whole of body-whorl (even more so than in *pulchra*), disappearing only on fasciole. Spiral ridges very thin, raised and distant, two on periphery and four on base rather stronger, not much weaker on shoulder.

Cominula (Procominula) praecox n. sp.

Shell simulating *C. exsculpta* (Suter), but with axial ribs as wide as or wider than interstices. Axial ribs 10 per whorl, vanishing half-way down body-whorl, but strong on shoulder. Spirals thin and distant, but rather more raised than in *exsculpta*. Early whorls not so sharply angulate; apex considerably smaller.

Height, 15·5 mm.; diameter, 7 mm.

Locality.—Wharekuri greensands.

Type in Finlay collection.

KEY TO THE SPECIES OF PROCOMINULA.

Spirals inconspicuous, very numerous and fine.
Spirals uniform, with sublinear grooves between.
9–10 axial ribs .. .. ***denselirata.***
13 axial ribs .. .. ***propinqua.***
Three to four distant, more prominent spirals on base.
11–13 axial ribs .. .. ***pukeuriensis.***
Spirals strong, raised ridges.
Axial ribs half as wide as interstices.
Shell squat, sculpture weak on shoulder, whorls angulate below middle .. .. ***pulchra.***
Shell elate, sculpture strong on shoulder, whorls angulate above middle .. .. ***exsculpta.***
Axial ribs as wide as interstices .. .. ***praecox.***

Cominista chattonensis n. sp. (Plate 58, figs. 5, 6.)

Shell of moderate size, sharp-spired, with distant blunt tubercles and spiral grooves. Apex tiny, paucispiral, papillate. 10–11 axial ribs per whorl, present only on lower half of spire-whorls and reduced almost to elongate blunt and strong tubercles on periphery of body-whorl, interstices 2–3 times their width. Surface scored with distant spiral grooves, with irregular finer ones between. Indications of 6 narrow brown colour-bands. Spire as high as aperture, very sharp, sides straight. Whorls medially angled, shoulder steeply sloping, slightly concave, straight below. Base almost straight, regularly tapering; suture distinct, slightly undulating. Aperture pyriform, angled above, narrowly but widely open below as an indistinct short canal. Outer lip thin and sharp, smooth inside. Inner lip smooth, with a practically straight edge, raised below where there is a chink-like opening left between it and the strong roughened fasciole, which has a sharp inner edge and an outer keel. Pillar slightly oblique, hardly excavated above, narrowly twisted and then recurved vertically downwards to a sharp point, with no groove. Parietal wall rather heavily calloused. Canal deeply notched behind.

Height, 32 mm.; diameter, 16·5 mm.

Locality.—Chatton sands, Southland (Ototaran ?); several specimens.

Type in Finlay collection.

A near relative of the Recent *glandiformis* Reeve (= *lurida* Phil.), but with sharper periphery, fewer and more nodular spirals. Also somewhat like the Australian *eburnea* Reeve, but more nodular and inflated.

Cominista obsoleta n. sp. (Plate 58, figs. 3, 4.)

Shell small, with obsolete sculpture and long faintly-notched canal. Apex worn. About 18 elongate peripheral small nodules per whorl, absent on shoulder and near lower suture, entirely obsolete on body-whorl, which is almost smooth and rounded. Body-whorl with numerous flat subequal spiral cords, interstices linear; worn off spire-whorls. Spire shorter than aperture, outlines faintly convex. Whorls rounded, very faintly submedially shouldered. Sutures indistinct. Aperture pyriform, angled above, with a rather long oblique open canal below, its base but little notched. Outer lip with fairly strong wide sinus at periphery, and with some thin distant teeth within. Fasciole very weak.

Height, 15 mm.; diameter, 13·5 mm.

Locality.—Nukumaru (Nukumaruian); two specimens.

Type in Finlay collection.

A very aberrant form, somewhat like a miniature *C. maculosa*, but the details of sculpture and aperture seem to fix its relationship with *Cominista*, though the canal is longer and less notched, and the pillar less recurved than usual. It seems, however, to be closely connected with the Recent *glandiformis* Reeve, and may be an offshoot from this line.

Acominia ridicula n. sp. (Plate 58, figs. 1, 2.)

Shell of moderate size, squarely inflated, massive. Apex lost. Ten low blunt axial ribs per whorl on the early whorls (interstices narrower), but these very soon become obsolete, and last three whorls are smooth except for numerous irregular spiral scratches, and 3–4 better-defined low close cords on base. Spire about half height of aperture, small and sharp,

projecting from the massive squarish body-whorl, outlines a little concave. Early whorls subangled, later ones flatly rounded, body-whorl subshouldered almost at level of suture, below this convex on left side, faintly concave on right side, due to swelling of upper part of whorl near aperture. Suture canaliculate. Aperture elongate, suboval centrally, running up to a long narrow point at the posterior channel, and open below at the short deep canal. Outer lip thin and sharp, almost straight, much thickened and smooth inside. Inner lip well defined, not raised except past fasciole, where a narrow umbilical chink is formed; a very heavy parietal callus. Pillar massive, straight, excavated above, very strongly twisted below, without groove. Fasciole narrow, lamellose. Canal very deeply notched behind.

Height, 36 mm.; diameter, 24 mm.

Locality.—Clifden, Southland, band 6c (Ototaran ?); one adult and one juvenile.

Type in Finlay collection.

Ancestral to the Recent *A. adspersa* (Brug.), which also often develops a squarish body-whorl, but relatively more massive, with smaller aperture, narrower notch, and weaker spiral sculpture. Other forms in the same line are *errata* Findlay* and *hendersoni* Marwick (this volume, p. 322).

Vesanula chaskanon n. gen. et sp. (Plate 56, figs. 20, 21.)

Shell of moderate size, with crass winged varices and flaring mouth. Apex worn, but apparently polygyrate and mamillate, the nuclear whorl somewhat asymmetrical. One or two faint low broad spirals on otherwise smooth shoulder; an angular frill at periphery, and below it about 11 low broadly-rounded spiral cords on body-whorl, the first two or three with narrow smooth furrows between, some on base with a fairly wide threadlet in interstices, those on canal closer; about 3 cords visible on spire-whorls. Numerous crispate growth-lines everywhere render spirals lamellar. 13-15 rude subobsolete axial ribs per whorl, absent on shoulder, strongest on periphery (interstices subequal or wider), very irregularly developed on body-whorl, fading out gradually on canal. Irregular very crass varices on last whorl of adult shells, about three stronger than others, thick and broad, frilled and lamellar with spiral and axial sculpture, projecting high above surface in front, especially at periphery. Spire not quite equal to aperture with canal, outlines straight. Whorls sharply carinate below middle, shoulder wide, sloping, thence cut in to suture which is not well marked. Aperture Trophonoid. Outer lip with a sharp frilled outer edge, suddenly much thickened inside, with 7 sinuous cord-like lirae running over the rampe to the frills; straight and slightly sloping at shoulder, with a shallow spout-like canal at periphery. Inner lip indistinct, smooth. Aperture prolonged basally into an almost straight narrowly open canal, longer than aperture itself. Pillar almost straight, strongly twisted at origin of canal. Fasciole weak, but marked by projecting terminations of previous canals.

Height, 21·5 mm.; diameter, 12 mm.

Locality.—Ardgowan "shell-bed" (Awamoan); several specimens. Also Target Gully.

Type in Finlay collection.

* New name proposed in *Proc. Mal. Soc.*, vol. 16, pt. 2, p. 103, 1924, for *Cominella carinata* (Hutt.), preoccupied.

The sculpture, aperture, and apex give this shell a peculiar facies, and I cannot allot it to any known austral group. A congeneric species seems to be *Fusus tegens* Hutton, from White Rock River (of which the later *Fusinus congestus* Suter, from the same locality is a synonym); this certainly has a mamillate, polygrate, symmetrical apex, and differs chiefly in its smaller, more slender shell, and much longer canal. *Pagodula vegrandis* M. & M. is superficially similar, but the embryo is radically different.

Aphera (?) scopalveus n. sp. (Plate 56, figs. 14, 15.)

Shell small, ovately fusiform, with fine dense spiral sculpture. Apex large, globose, of 2 smooth whorls, the first considerably heterostrophe. Fine dense spiral grooves over whole surface, cutting up shell into low flattish spiral cords, finely reticulated by numerous thickish growth-lines. Spire lower than aperture, outlines almost straight. Whorls regularly lightly convex. Suture subchannelled, but this may be due to wearing. Aperture pyriform, narrowly angled above, with a very indistinct widely open canal below, not notched at base. Outer lip thickened, heavily lirate inside. Inner lip well marked as a smooth glaze. Pillar stout, vertical, with 3 plaits, the upper two very strong (the uppermost more so), the lowest feeble, margining canal; a weak short denticular plait between each pair at margin of inner lip. Imperforate.

Height, 18 mm.; diameter, 9·5 mm.

Locality.—Target Gully "shell-bed" (Awamoan); two specimens.

Type in Finlay collection.

This shell is only provisionally placed; it seems congeneric with *Cancellaria lactea* Desh. (= *laevigata* Sow.) and *C. purpuriformis* Kuster, but I hesitate to make a new group for them without further knowledge of the Australian shells.

Family VOLUTIDAE.

Most of the following new Volutes are not correctly located generically. Several need new genera, but as Dr. Marwick has this in hand I create no new groups for these shells, and place them where Suter placed similar shells.

Miomelon clifdenensis n. sp. (Plate 55, figs. 1–3.)

Shell small, strongly corrugated, with subnodulous keel on lower whorls, excavated shoulder, sharp apex, and wide aperture. Apex Caricelloid, of essentially same type as in *M. parki* Suter, but more narrowly cylindrical and with higher whorls. About 4½ adult whorls, very rapidly increasing. Spire-whorls with a lightly concave depression on upper half, lower half almost straight; this develops till later whorls bear a strong shoulder, very prominent on body-whorl, where the subsutural excavation is markedly concave. Effect of this shouldering strengthened by ribs, which, though practically absent (except for growth-lines) on first 2–3 whorls, rapidly develop into strong axials, 12–13 on body-whorl. Ribs begin as growth-ridges at suture, suddenly swell to blunt nodules on keel, thence taper off gradually and slope backwards on base, vanishing just before fasciole; interstices about 2½ times width of ribs. Distinct spiral scratchings over whole surface. Body-whorl remains of uniform inflation for some distance below keel, suddenly contracts to fasciole, and thence tapers very little. Spire about half height of aperture. Aperture with subparallel sides or

inflated at base, constricted posteriorly by shoulder depression. Outer lip sharp-edged, but thickened within. Inner lip not defined, limited to thin glaze. Columella almost straight but oblique, stout and not much tapered below, with 5 plaits, uppermost weakest. Basal notch very strong, Buccinoid, marked by strong fasciole, sharply keeled on outer edge by raised ridge.

Height, 41·5 mm.; diameter, 18 mm.; height of aperture, 27·5 (type). Height, 50 mm.; diameter, 20 mm.; height of aperture, 33 (paratype).

Locality.—Clifden, Southland, bands 6A (type) and 6B (Ototaran ?); three specimens.

Type in Finlay collection.

Miomelon reverta n. sp.

Very close to previous species in all details of shape and sculpture, but with less-developed keel, there being but little shoulder-excavation, and hardly any keel on spire-whorls. Axial ribs developed only on inflated part of body-whorl, quite absent when base begins to contract. Spire, aperture, and fasciole as in last species, but columella with only 4 plaits, all well developed, wider apart and less oblique than in *M. clifdenensis*; top plait from its position is evidently the highest, so a fifth internal plait is probably not present. Columella thicker at base than in last species, and bent to left instead of right, so that anterior end of shell forms a rather prominent snout.

Height, 48·5 mm.; diameter, 20·5 mm.; height of aperture, 33 mm.

Locality.—Target Gully; one specimen.

Type in Finlay collection.

Miomelon inermis n. sp.

In shape and shell-formation corresponds almost exactly with *M. clifdenensis*, but totally without axial sculpture. Apex Caricelloid, but apparently not rising to so sharp a point. All whorls smooth except for growth-lines and spiral scratches. A faint keel and straight shoulder sometimes developed on body-whorl, more often absent, whorls being regularly lightly convex. Shape of body-whorl, relative height of spire, inner lip, basal notch, fasciole, and columellar plaits as in *M. clifdenensis*. Outer lip, however, more flaring posteriorly, due to absence of shoulder-excavation.

Height, *circa* 44 mm.; diameter, 18·5 mm.; height of aperture, 29 mm.

Locality.—Otiake, sandy beds above the limestone (Awamoan); six specimens.

Type in Finlay collection.

Alcithoe regularis n. sp. (Plate 55, fig. 4.)

Superficially similar to *M. clifdenensis*. Apex lost, but almost certainly Caricelloid. Spire less staged, more regularly attenuated. Axial ribs of same character but thinner, not nodular at keel, present on all whorls and more numerous (16–17 per whorl), interstices about twice their width. Spire-whorls with hardly any keel, body-whorl with a blunt angulation, but keel and shoulder excavation much weaker than in *M. clifdenensis*. Anterior attenuation of shell begins sooner and is greater. Spire three-quarters height of aperture, which is as in *M. clifdenensis*, except that widest

at keel, attenuated below. Inner lip better marked by smooth excavated area. Basal notch much weaker; fasciole hardly marked, with no marginal keel.

Height, 42 mm.; diameter, 17·5 mm.; height of aperture, 24 mm.

Locality.—Clifden, Southland, band 8 (Awamoan ?); one specimen.

Type in Finlay collection.

Distinguished from the Pareora shells identified by Suter as *M. corrugata* (Hutt.) chiefly by considerably greater inflation.

Alcithoe bathgatei n. sp. (Plate 56, figs. 4, 5.)

Shell small, attenuated, with numerous persistent axial ribs, slightly nodular on keel. Protoconch of 2½ whorls, apical one extremely vertically compressed, so that whole top is flattened. Adult whorls 6, slightly keeled at about middle, concave above, straight below. Body-whorl short, rapidly contracted to base. 12–15 slender axial ribs per whorl, sloping slightly forward from suture to suture, but thicker on lower half of whorls, forming small, fairly sharp tubercles on keel, vanishing only near fasciole; interstices 3–4 times their width. About 16 flattish inconspicuous spiral cords with linear interstices on upper whorls, absent lower down. Spire higher than aperture; suture oblique, distinct. Aperture short, narrow, basal notch weak, fasciole but slightly raised. Columella thick, slightly oblique, with 4 strong oblique plaits and occasionally a fifth weaker one above. Inner lip definite, smooth, slightly excavated.

Height, 51 mm.; diameter, 15 mm.; height of aperture, 25 mm. (type, from band 4A). Height, 49 mm.; diameter, 16 mm.; height of aperture, 24 mm. (paratype, from band 6A).

Locality.—Clifden, Southland, bands 4B (type) and 6A (Ototaran ?); several specimens.

Type in Finlay collection.

Deceptively similar to the Pliocene *A. morgani* M. & M., but easily distinguished by much smaller size, shorter body-whorl, flat apex, and different details of sculpture.

Alcithoe phymatias n. sp. (Plate 56, figs. 1–3.)

A development of the last species in which the body-whorl bears only a few (but very strong) spines. Protoconch of same style but larger, almost quite flat on top. Shell constantly wider, with spire lower than aperture. Body-whorl tapering almost at once below keel, base outlines practically straight. First few whorls with same sculpture as previous species, but from third whorl onwards axials begin to space out and become evanescent on shoulder, especially on last two whorls, where, in adult shell, ribs become quite obsolete, their place being taken by long stout spines on periphery, 6–7 on last whorl, ribs quite absent on base except in young shells. Spiral sculpture, basal notch, and columella as in last species; aperture a little longer.

Height, 49 mm.; diameter, 25 mm.; height of aperture, 25 mm. (type). Height, 58·5 mm.; diameter, 25 mm.; height of aperture, 32·5 mm. (paratype). Height, 39·5 mm.; diameter, 16·5 mm.; height of aperture, 21·5 mm. (paratype).

Locality.—Clifden, Southland, band 6B (Ototaran ?); several specimens. Type in Finlay collection.

Alcithoe residua n. sp. (Plate 55, fig. 5.)

Shell large, with many curved axial ribs over all whorls. Protoconch of 3 whorls, last narrow and encroached on above and below; apex free, granular, and bluntly pointed. Five adult whorls, rapidly increasing, last very large, regularly convex except for slight shoulder-depression on upper half. Narrow curved axial ribs (interstices twice their width) on all whorls, 17 on first, 22–24 on remainder; on body-whorl they tend to disappear on shoulder and thicken at their bases on periphery, interstices consequently seeming narrower. About 5 faint irregular and distant linear spiral cords on lower two-thirds of spire-whorls. Columella and lower part of shell missing; outer lip thick, slightly expanded, with distinct posterior channel and callus-pad.

Height of what remains, 123 mm.; diameter ?

Locality.—Otiake, sandy beds above the limestone (Awamoan); one specimen.

Type in Finlay collection.

Though the shell is so much fractured, the size, sculpture, and apex will sufficiently characterize the species.

Alcithoe dyscrita n. sp. (Plate 55, fig. 9.)

Shell small, biconic, with numerous persistent axial ribs produced into regular prominent spines on a sharp periphery. Tip of protoconch lost, but remainder seems similar to that of *bathgatei* and *phymatias*. Four shell-whorls in unique specimen, which, however, is probably juvenile. A sharp submedian carina on all whorls, continued as a pronounced peripheral keel on body-whorl, below which base tapers rapidly for half its length, then more slowly towards beak. Shoulder concave, suture distinct, wavy. Eleven axial ribs on all whorls, extending from suture to suture on first two whorls, then becoming much broader and subobsolete on shoulder, but persistent for half the distance below keel on body-whorl; interstices twice width of ribs. On keel of every whorl ribs develop sharp prominent tubercles, strongest and probably high on body-whorl, but all broken off, leaving only thick stumps. Spire little more than half height of aperture. Outer lip broken, aperture oblique, with subparallel sides. Columella stout, oblique, with 4 sharp plaits. Basal notch slight, practically no fasciole.

Height, 33 mm.; diameter, 19 mm.; height of aperture, 21 mm.

Locality.—Clifden, Southland, band 6C (Ototaran ?); one specimen.

Type in Finlay collection.

Easily distinguished from *A. phymatias* by squat form and many tubercles.

Scaphella cognata n. sp. (Plate 56, fig. 7.)

Very similar to *S. elegantissima* Suter (*N.Z. Geol. Surv. Pal. Bull. 5*, p. 41, pl. 5, fig. 9, 1917), but differs in less attenuated shell, lower spire (two-thirds of aperture instead of nearly as high), much less contracted and therefore less tapering base, and fewer columellar plaits (only 4 in

both adults and juveniles). Whorls also not flat, but with distinct subkeel just below middle; each of first three whorls bears about 19 slightly arcuate axial riblets, with interstices twice their width. Protoconch of this and next two species as in *S. elegantissima;* spiral sculpture in all four species limited to faint scratches, often absent.

Height, 55 mm.; diameter, 18 mm.; height of aperture, 33 mm.

Locality.—Target Gully "shell-bed" (Awamoan); two specimens. One doubtful fragment from Otiake.

Type in Finlay collection.

Scaphella tumidior n. sp. (Plate 56, fig. 6.)

Characterized by relative tumidity and short and concave spire. Whorls almost straight, but showing a very faint blunt keel, nearly hidden by lower suture. This and the rather disproportionate widening of later whorls give the short spire an attenuated aspect, and render its sides slightly concave. First two whorls each with about 22 small sloping riblets, own width or less apart, later whorls smooth. Spire about half height of aperture. Base rapidly contracted and much narrower anteriorly than in preceding species. Basal notch in this and next species not symmetrically vertically placed as in *S. cognata*, but cutting in from side; columella therefore descending much lower than outer lip. Five columellar plaits, uppermost very weak.

Height, 43 mm.; diameter, 15 mm.; height of spire, 29·5 mm.

Locality.—Otiake, sandy beds above the limestone (Awamoan); three specimens.

Type in Finlay collection.

Scaphella pretiosa n. sp. (Plate 55, figs. 7, 8.)

This is the nearest of these three new species to *S. elegantissima* Suter, being narrow and attenuated towards both extremities, but differs in growth of shell and sculpture. Whorls all regularly increasing, almost flat, but showing slight keel near lower suture, no tumidity in body-whorl. Below keel on body-whorl base is very gently and regularly contracted, outlines being straight or slightly convex, not concave as in *S. elegantissima.* Spire a trifle lower than aperture. About 17 almost linear, slightly sloping, axial ridges per whorl, present on all spire-whorls and part of body-whorl, interstices 3–6 times their width. Four columellar plaits.

Height, 52 mm.; diameter, 14·5 mm; height of aperture, 28 mm.

Locality.—Clifden, Southland, band 6A (Ototaran ?); two specimens.

Type in Finlay collection.

Distinguished from *S. cognata* by more fusiform shape, different axial sculpture, lower keel on spire-whorls, &c.

Miomelon benitens n. sp. (Plate 55, fig. 6.)

Shell fairly large but thin, almost smooth, polished. Protoconch Caricelloid, smooth, of about 2½ turns, last whorl narrowest, encroached on above and below; apex granular, produced into a sharp high pinnacle. Next three whorls with numerous more or less indistinct slightly curved axial riblets, later whorls perfectly smooth except for obscure and irregular spiral markings. Shell-whorls 5, slightly depressed and concave below

suture, otherwise regularly convex. Whole shell more or less polished, especially aperture and front of body-whorl. Suture distinct, simple. Body-whorl gently attenuated to base. Spire half height of aperture. Aperture rather wide and flaring, but outer lip lost below. Columellar margin oblique, almost straight; plaits hardly apparent till shell turned side on, when 6 strong plaits can be counted; upper two more distant and uppermost, shorter than others, lowest continuing vertically as prolongation of columella, ending in sharp point at base of shell, considerably past end of outer lip. Basal notch subrectangular, not deep, fasciole broad but almost indistinguishable from rest of shell, traversed near columella by a strong blunt carina, ending just above third highest plait. Inner lip not marked except for a wide semicircular polish extending from above aperture outwards over whole front of body-whorl down to extremity of shell.

Height, 106·5 mm.; diameter, 35 mm.; height of aperture, 68 mm.

Localities.—Otiake, sandy beds above the limestone (Awamoan); one adult and several fragments. Also one apical fragment from Blue Cliffs (Dominion Museum collection).

Type in Finlay collection.

Baryspira waikaiaensis n. sp. (Plate 56, figs. 18, 19.)

Shell of the *mucronata* line, small for that group, with a very blunt heavy top. A few flattened whorls of the nucleus are just visible through the shining callus. Spire very short and depressed, angle about 110°, top bluntly pointed. Callus very heavy, spread directly outwards as a thick tongue-shaped pad, quite to the left side of shell, not granulose but minutely marked with tiny elongate punctures. The two bands above fasciole are about same width (upper sunken one narrower in type, which has sustained a fracture). Aperture filled with matrix, but what can be seen of it and of pillar agrees with *mucronata.*

Height, 26 mm.; diameter, 14 mm.

Locality. — Waikaia, in shelly limestone (Ototaran?) one good shell and several damaged ones.

Type in Finlay collection.

Distinguished by small shell, low spire, and heavy callus.

Comitas and Insolentia n. genera.

The genus *Turricula* contains a great number of widely-differing forms, unnaturally bound together by the common possession of a sinus on the shoulder and a long canal. These two features occur in very many stocks of Turrids, and should not be used as primary generic characters to the neglect of, say, radical embryonic differences. In New Zealand Tertiary beds this kind of shell is well represented, though none of the species is congeneric with *Murex tornatus* Dilwyn, the tropical genotype of *Turricula,* and the forms may be very roughly divided into those with paucispiral papillate embryos and those with polygyrate conic pointed apices. For the former I propose *Comitas* n. gen., naming *Surcula oamarutica* Suter, from Target Gully (Awamoan), as type (*N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 51, 1917). That shell has a two-whorled papillate apex, the nucleus minute, lobate, and flattened down, giving the top a bluntly-pointed (but not acute) appearance, the last whorl developing a strong but not sharp carina. Most of the Neozelanic species may be included here; for the others that

are sharply pointed I propose *Insolentia* n. gen., with *Surcula pareoraensis* Suter (= *boliquecostata* Suter) as type (*N.Z. Geol. Surv. Pall. Bull. No. 3*, p. 36; *No. 5*, p. 52). That species has the protoconch polygrate, conic, consisting of 3 smooth convex whorls, the nucleus pointed, followed by a wider whorl with curved axial riblets.

Zemacies n. gen.

A series of shells from the New Zealand early Tertiary beds, comprising *Surcula torticostata, marginalis, ordinaria*, all of Marshall, and *Pleurotoma hamiltoni* Hutton, may be genetically allied to *Apiotoma* Cossmann, but are larger, less staged, and more slender shells, with a very deep anal sinus on shoulder, the outer lip swinging out far past its origin at suture. Cossmann (*Essais de Pal. Comp.*, livre. 2, p. 73, 1896) remarks that *Apiotoma* has an " embryon conoidal, à bouton mamillé " ; but the New Zealand shells have a protoconch almost similar to that of *Insolentia* n. gen., regularly conic, polygrate, pointed, with a few curved axial riblets at its close. As I have not seen any examples of the above-named species with well-preserved apices, it is not right to fix any of them as type of a genus based mainly on embryonic features; I therefore describe a new species from Clifden as *Zemacies elatior* and name it as type. *Zemacies* and *Insolentia* are probably closely allied; the Australian *Apiotoma bassi* Pritchard, though superficially similar, has a different apex, and seems to be a true *Apiotoma*.

Zemacies elatior n. gen. and sp.

Shell large, very slender. Apex as already described. About 12 spiral cords below shoulder on spire-whorls (interstices twice their width, with a few finer interstitial riblets), numerous fine threads above; spirals continued, alternately fine and weak, all over body-whorl. Axial ribs confined to early whorls, about 20 per whorl, appearing only as elongate forwardly-sloping nodules on keel, vanishing half-way to lower suture; lower whorls only irregularly corrugated and roughened by growth-lines. A low thin sharp cord margins a small subsutural straight and sloping platform as in *S. marginata* Marshall; below this shoulder is concave, then whorls have a blunt supramedial keel, then slope slightly in to lower suture. Spire high, as long as aperture with canal. Suture distinct, aperture long and narrow, outer lip as already described, the sinus very deep and narrowly rounded, its apex at centre of concave shoulder. Pillar oblique but quite straight, very long and regularly tapering, no trace of folds. Canal not notched, its base spout-like.

Height, 75 mm. (plus about 5 mm. missing from apex of type); diameter, 17 mm.

Locality.—Clifden, Southland, band 4 (Ototaran); several specimens.

Type in Finlay collection.

Very near *marginalis* Marshall, but differing from all the New Zealand allied species in its greater tenuity.

Speightia n. gen.

Woods, in Bosworth's *Geology of the Tertiary and Quaternary Periods in the North-west Part of Peru* (p. 106), has described two very interesting shells as *Surcula occidentalis* n. sp. and *S. thomsoni* n. sp. As far as can be told without handling actual specimens, these seem congeneric with

Euthriofusus spinosus Suter (*N.Z. Geol. Surv. Pal. Bull. 5*, p. 24, 1917). This is not related to *Euthriofusus*, as Dr. Marwick, when describing *E. tangituensis* n. sp., has also mentioned (this vol., p. 320), but is a Turrid, probably of a Clavatuline genus. Woods says that *S. occidentalis* " shows a general resemblance to the form named *Pleurotoma acutinoda* by Philippi " ; but the group is so distinct that comparisons are hardly justified. Accordingly I propose the above name, and fix *E. spinosus* Suter as type. It is, of course, unsafe to locate extra-limital fossils definitely in a Neozelanic genus from a knowledge only of their figures and descriptions, and the Peruvian shells may quite easily turn out to be only superficially alike and not really related ; I would thus name *Speightia* as a Neozelanic genus and only tentatively assign Woods's species to it until actual specimens are available. The absence, as far as we yet know, of geographically intermediate relatives in both countries, and of ancestral forms, makes one feel somewhat suspicious of their apparent close relation. *E. spinosus* Suter occurs in the Waihao Downs, McCullough's Bridge, and Hampden beds (Eocene), but commonly only in the first-named, while the Peruvian species come from the Negritos formation, which Woods regards as Eocene.

Austrotoma scopalveus n. sp. (Plate 57, figs. 19, 20.)

Shell moderately large, with strong cancellate ornament, deep basal notch, and keeled fasciole. Protoconch rubbed, but probably as described for *A. excavata* (Suter) (Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 515, 1924). About 24 broadish slightly-forwardly-sloping axial riblets per whorl (interstices subequal or a little wider), starting at shoulder and reaching lower suture, more or less obsolete on body-whorl and frequently on penultimate and antepenultimate also. Shoulder with a few distant fine spiral threads and curved sinus growth-lines, rest of shell with strong raised spiral cords, 5 on spire-whorls, 15 on body-whorl (interstices twice their width, frequently with 1 or 2 interstitial riblets), slightly undulated by axial ribs. Spire higher than aperture, outlines faintly convex. Whorls shouldered above middle, strongly concave above, straight below. Whorls clasping, suture inconspicuous, margined by a spiral cord above and by very oblique rough growth-lines below, a slight ridge between these and the concave shoulder. Aperture elongate-pyriform, angled above, gradually tapering below to a widely-open rather long canal with a deep basal triangular notch. Outer lip thin and sharp, with a Genotiform sinus on shoulder, curving forward below. Inner lip indistinct, spread as a thin gloss over parietal wall and pillar, which is slightly oblique, thick, bulging a little medially, and slowly tapered off to a point, reaching below outer lip. Fasciole sunken, lamellose, bounded by a low blunt angulation anteriorly and a sharp strong cord-like keel behind, continued from the side of the notch.

Height, 41 mm. ; diameter, 18 mm.

Locality.—Target Gully " shell-bed " (Awamoan) ; fairly common.

Type in Finlay collection.

Austrotoma obsoleta n. sp. (Plate 55, figs. 13, 14.)

Shell with the generic characters of the last species, but shorter and with axial ribs only faintly present on first few whorls. Seven spiral cords on spire-whorls, the upper three forming a very strong subsutural ridge, then a narrow deeply concave smooth sinus space, then the lower four ;

12–14 spirals between this space on body-whorl (interstices wider, deep, sometimes with interstitial threads). Shell squat, with spire shorter than aperture. Pillar more excavated above than in previous species, and canal shorter; other details same.

Height, 26·5 mm.; diameter, 12·5 mm.

Locality.—Lower Waipara sandy beds (Tongaporutuan ?), with *Zelandiella fatua* n. sp. (see reference, p. 237 of this volume); four specimens.

Type in Finlay collection.

An aberrant form in which axial sculpture has almost disappeared.

Fenestrosyrinx n. gen.

I name *Turris nexilis bicarinatus* Suter (*N.Z. Geol. Surv. Pal. Bull. 3*, p. 34, 1915) as type of this group, which consists of a series of small shells with strong reticulate sculpture, sinus triangular at the keel, and delicately reticulate apex with the spirals stronger. Of this species *Leucosyrinx thomsoni* Mestayer is a synonym; I have compared the types and paratypes of both, and their identity is certain. The shell has no relation to *Leucosyrinx*. Suter's subspecies *bicarinatus* is doubtfully separable from *nexilis* itself, and the figure is extremely crude, but the name may be retained till more shells bridging the differences are collected. *Bathytoma gratiosa* Suter is another member of *Fenestrosyrinx*, while the Australian *Hemipleurotoma mayi* Verco, *Asperdaphne vestalis* Hedley, and *Daphnella granata* Hedley, while emphasizing the number of locations these shells have had, would easily fall into this group. True *Asperdaphne* is a much larger shell, with different apex and anal sinus.

Stilla n. gen.

Mangilia flexicostata Suter will not connect with any group of Turrids. Nothing like it in Australia is known to me, but I have a new congeneric Recent shell from New Zealand. The minute size, Daphnellid sinus, and simple axial sculpture render this little group quite conspicuous, and I name *M. flexicostata* Suter as type of the above new genus. Hedley regarded the species as a *Nepotilla*, but that genus has an extremely deep sinus like *Veprecula* and predominate spiral keels. True *Nepotilla* is also known to me by undescribed species from New Zealand.

Vexithara n. gen.

More attention has been paid to Mitromorphoid shells within recent years. Iredale (*Proc. Mal. Soc.*, vol. 12, pt. 6, p. 328, 1917) has discussed these forms and outlined four genera:—

- *Mitromorpha* Carpenter, with type *M. filosa* Carp., including *Columbella dormitor* Sow.
- *Lovellona* Iredale, with type *Conus atramentosus* Reeve, including *Conus parvus* Pease and *C. micarius* Hedley.
- *Apaturris* Iredale, with type *Mitromorpha expeditionis* Oliver.
- *Antimitra* Iredale, with type *Pleurotoma aegrota* Reeve, including *Mitromorpha lirata* Adams and *Daphnella crenulata* Pease.

Hedley has discussed the Australian *Mitromorpha* complex (*Rec. Austr. Mus.*, vol. 13, p. 259, 1921), distributing the forms in *Prosipho*, *Teleochilus*, *Scrinium* n. gen. for *M. brazieri* Smith, and *Mitrithara* n. gen. for *Columbella*

alba Petterd. The Recent Neozelanic *Mitromorpha gemmata* Suter and the fossil *Borsonia brachyspira* Suter belong to the last-named group, but there is a "Miocene" group, comprising *Antimitra vexilliformis* Marshall and Murdoch, *Pleurotoma hebes* Hutton, and *Ptychatractus nodosoliratus* Suter, that will not fall into any of the above genera, and for which I propose *Vexithara* n. gen., with the first-named as type. Suter's reference of *P. hebes* Hutton to *Lapparia (N.Z. Geol. Surv. Pal. Bull. 5*, p. 40, 1917) is due to his confusion of two quite different shells, a Volute (*loc. cit.*, pl. 12, figs. 11, 12), and a Turrid (pl. 5, fig. 8). The reference of *nodosoliratus* to *Ptychatractus* has, as I have already remarked (*Trans. N.Z. Inst.*, vol. 55, p. 500, 1924), little to justify it. Marshall and Murdoch's figure of *vexilliformis* (*loc. cit.*, vol. 54, pl. 13, fig. 3) and the good illustration of *nodosoliratus* (*N.Z. Geol. Surv. Pal. Bull. 5*, pl. 12, fig. 23, 1917) well show the style of these shells.

Conospira rivertonensis n. sp. (Plate 56, fig. 13.)

Shell of moderate size, rather slender, with nodular periphery and exsert spire. Apex lost. Twenty-two small vertically elongate nodules per whorl on the peripheral carina (interstices twice their width); no other axial sculpture except slightly curved growth-lines. Two spiral grooves crossing lower part of nodular row; upper half of body-whorl smooth, lower half with a number of grooves, faint above and with wide spaces between, closer and stronger below. Spire half height of aperture, outlines faintly convex. Whorls medially sharply carinate, straight above and below, shoulder steep, then sloping in below. Suture distinct. Aperture very long, slot-like, angled above, open below, base not notched. Sinus typical, fairly deep on shoulder, very gentle curve below. Pillar straight, slanting, with a single interior very oblique twist and deep groove low down.

Height, 33 mm.; diameter, 12 mm.

Locality.—Pourakino sands, Riverton (Ototaran ?); one specimen.

Type in Finlay collection

Related to *Conospira** *bimutata* Finlay (*Trans. N.Z. Inst.*, vol. 55, p. 498, 1924), but readily distinguished by longer and more exsert spire and narrower shell.

Neilo awamoana n. sp. (Plate 58, figs. 20–22.)

Shell ancestral to *N. australis* (Q. & G.), but thicker and heavier, more inflated, with different sculpture, not so straight on top. Concentric ribs lower, wider and blunter, more numerous on posterior area, which is much less flattened and wing-like, with its bordering angulation blunter and less raised. Two other faint angulations traverse it, as in the Recent species. Shell quite thick, tumid, the dorsal margins both sloping away from the umbo. Hinge altogether much heavier and relatively wider, with very high and sharp teeth. Pallial and muscle impressions better marked. Other details as in *N. australis*.

Length, 37 mm.; height, 21·5 mm.; width (one valve), 8 mm.

Locality.—Mount Harris (Awamoan), type; also Pukeuri, Awamoa, Ardgowan (fig. 20), Devil's Bridge (fig. 22), &c. The common Awamoan *Neilo*.

* Misspelt "*Cenospira*" at the reference quoted.

Neilo sinangula n. sp. (Plate 58, fig. 19.)

Close to the preceding species, but generally with a rounder basal margin, more indistinct and irregular sculpture, very ill-marked posterior angulation, and no secondary angulations traversing posterior dorsal area. Posterior dorsal margin concave, posterior end more produced and winged, the truncation faintly convex, not sinuate. Sculpture tends to be reduced on posterior dorsal area to growth-laminations alone. Other details as in previous species.

Length, 27 mm.; height, 16 mm.; width, 5 mm. (type). Length, 36 mm.; height, 20·5 mm.; width, 7 mm. (paratype).

Locality.—Wharekuri greensands (Ototaran ?); not uncommon.

Type in Finlay collection.

Spissatella n. gen.

*Crassatella traill*i Hutton (*Cat. Tert. Moll.*, p. 24, 1873) is put forward as type of this new group of Crassatelliform shells, to which the majority of the New Zealand fossil forms belong. *Talabrica* Iredale (*P.L.S. N.S.W.*, vol. 49, p. 204, 1924) applies to the "*bellulus*" series; *Salaputium* Iredale (*loc. cit.*) has no New Zealand representatives; and *Eucrassatella* Iredale (*loc. cit.*, p. 202) is available only for the large forms such as *amplus* (Zittel) and *attenuatus* (Hutton). The "*trailli*" series, to which belong *subobesus* M. & M., *Astarte australis* Hutton, and all the forms here described, differs from *Eucrassatella* in size, character of initial ornament, hinge, and muscle-scars. The young shell is very like a *Salaputium*, which may represent an arrested stage in the development of *Spissatella*, but the hinge is again different. The members of the four genera above mentioned all have smooth margins, while the genotype of *Crassatellites* itself (*C. sinuatus* Krueger = *C. gibbosula* Lk.) has finely corrugated margins like the Australian *C. dennanti* Tate, which is apparently closely related to the genotype. Not a single "*Crassatellites*" with corrugated margins has yet been found in New Zealand.

Spissatella discrepans n. sp. (Plate 59, fig. 10.)

Shell subtrapezoidal, rather thin, inequilateral, depressed. Beaks at a little less than two-fifths of length from anterior end, pointed, considerably incurved, directed forward. Anterior end produced and attenuate; dorsal margin almost straight and sloping rapidly at about 45° for about two-thirds height of shell, then roundly angled to ventral margin. Posterior end much longer, subquadrate; dorsal margin slightly convex, very gradually sloping, then regularly rounded off and curving downwards and slightly inwards to meet ventral margin, which it does (at an angle of about 110°) at extremity of an almost straight low very blunt angulation extending from umbo; ventral margin just in front of this angulation faintly concave, then broadly rounded up to anterior end; posterior dorsal area faintly convex. Lunule not much excavated, long and narrow, its slope approximately same as that of dorsal margin. Escutcheon long, very narrow, practically straight. Sculpture of very fine regular concentric riblets, a little finer on posterior dorsal area, but not forming striae there; about 25 per centimetre on middle of shell, interstices a trifle narrower. Interior completely hidden by matrix, and shell too fragile and chalky to allow of this being removed. Margin smooth.

Length, 37 mm.; height, 14 mm.; width (one valve), 7 mm.; distance of beak from anterior end, 14 mm.

Locality.—Lake Wakatipu, sandstone below the limestone (Ototaran ?); one specimen.

Type in Finlay collection.

A type of shell different from most of the other small species of *Crassatellites* in New Zealand, which have inflated strong beaks, short anterior ends, and coarse ornament.

Spissatella accultа n. sp.

Closely related to previous species, but still more depressed and with still finer ornament. Anterior end not so pointed or produced, posterior end relatively considerably longer, posterior dorsal area narrower. Basal margin straighter. Beaks, lunule, and escutcheon the same. Posterior angulation somewhat wider and blunter, the dorsal area above it lightly concave. Shell everywhere still less inflated. About 30 very fine and low concentric ribs per centimetre on centre of shell, interstices linear.

Length, 44 mm.; height, 30 mm.; width (one valve), 8 mm.; distance of beak from anterior end, 12 mm.

Locality.—Wharekuri greensands (Ototaran ?); one specimen.

Type in Finlay collection.

Spissatella poroleda n. sp. (Plate 59, fig. 11.)

Shell depressed, with a narrow posterior wing, strongly convex basal margin, moderately fine sculpture; much the shape of a *Poroleda*. Beaks projecting, very acute, at anterior third of length. Anterior end fairly long, rather narrowly convex, much as in previous species. Posterior end long and tapering on both sides, dorsal margin lightly concave, suddenly narrowly vertically truncated. Basal margin everywhere markedly convex. Posterior dorsal area lightly concave, with a second sharp angulation near the dorsal margin. Shell of regular inflation, not depressed near angulation. About 14 lowly rounded narrow ribs per centimetre in centre of shell, interstices narrower but not linear, ribs ceasing at angulation, dorsal area only lamellose. Hinge and interior as in *C. traill*i Hutt. Margin smooth, narrowly bevelled.

Length, 41 mm.; height, 26 mm.; width (one valve), 6·5 mm.; distance of beak from anterior end, 14 mm.

Locality.—Chatton sands (Ototaran ?); one specimen.

Type in Finlay collection.

Related to *C. subobesus* Marsh. & Murd., and to the following species, but characterized by shape and thin depressed shell.

Spissatella trailli (Hutton, 1873). (Plate 59, figs. 13, 14.)

For "synonymy"—in this case, confusion with *S. obesa* (A. Ad.)—and description of type specimen, see Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 48, 1914. Easily distinguished from *S. obesa* (A. Ad.) (if one may judge from the description and figure of that shell, no specimen of which has since been found by local collectors, and which may be, as Iredale suggests, not Neozelanic at all, but a juvenile Australian *Eucrassatellites*, perhaps the Queensland *cumingii* A. Ad.) by different shape and finer sculpture

There are 13 rather raised, rounded, concentric sulci per centimetre in centre of shell, interstices furrow-like, a little narrower. This is the common Awamoan "*Crassatellites.*"

Type in N.Z. Geological Survey collection.

Spissatella clifdenensis n. sp.

Closely related to the previous species, but more massive, shorter and higher (and therefore less "tailed"), with rather weaker sculpture. Beaks very high and strong; no concave depression near posterior angulation, which is rather sharp; basal and posterior dorsal margins generally quite straight; posterior end more broadly truncated. Fourteen lowly rounded ribs per centimetre in centre of valves, interstices not quite linear. Other details as in *C. trailli.*

Length, 39 mm.; height, 30 mm.; width (one valve), 9·5 mm.; distance of beak from anterior end, 15 mm.

Locality.—Clifden, Southland, bands 4 (type), 6A, and 6B (Ototaran ?); not uncommon.

Type in Finlay collection.

Spissatella scopalveus n. sp. (Plate 60, figs. 7, 8.)

Shell close to *C. trailli*, but perfectly smooth, wedge-shaped posteriorly. For about 1 cm. or less from umbo there are concentric sulci as in *trailli*; rest of shell quite smooth except for growth-striae and occasional weak corrugations. Beaks rather incurved, a little blunted. Shell moderately tumid, flatly depressed postero-medially. Posterior truncation very oblique, making posterior end pointed and wedge-shaped. Margin not bevelled interiorly, rounded, and with a faint groove inside. Otherwise similar to *trailli.*

Length, 46 mm.; height, 32 mm.; width (one valve), 11 mm.; distance of beak from anterior end, 17 mm.

Locality.—Target Gully "shell-bed" alone (Awamoan); common.

Type in Finlay collection.

A curious smooth and produced local form.

Subspecies concisus n. subsp. (Plate 59, fig. 12.)

Differs only in being very short while of same height, and having posterior dorsal area and truncation considerably narrower. Basal margin slopes rapidly up to truncation.

Length, 38 mm.; height, 32 mm.; width (one valve), 10·5 mm.; distance of beaks from anterior end, 15 mm.

Locality.—Same as last, but much rarer.

Somewhat the shape of *C. clifdenensis* nov., but still more abbreviated and quite smooth.

Tertiary and Recent Volutidae of New Zealand.

By J. MARWICK, M.A., D.Sc., New Zealand Geological Survey.

[*Abstract read, by permission of the Director of the New Zealand Geological Survey, before the Wellington Philosophical Society, 8th October, 1924; received by Editor, 22nd December, 1924; published separately, 13th March, 1926.*]

Plates 61–70.

CONTENTS.

1. INTRODUCTION.

THE Volutes constitute one of the most beautiful and varied groups of the Mollusca, and include some of the rarest shells. As a result they have long attracted the attention of conchologists, and many subdivisions have been proposed with a view to their more accurate classification.

The modern study of the family dates from Dall's revision of 1890. His paper, though concerned principally with the Tertiary of Florida, covered much general ground, and proposed as a new major classification of the Volutidae two series which were later called subfamilies. This division was based on researches made by Dall into the manner of growth of the animals in their early stages, and was as follows:—

A. Volutoid series.
  Protoconch calcareous from the earliest stage.
    (*a.*) Trochiform nucleus.
    (*b.*) Bulbous nucleus.

B. Scaphelloid series.
  Protoconch at first horny.*
    (*a.*) *Caricella* type—nucleus with a sharp spike: *Voluta ancilla* Solander.
    (*b.*) *Scaphella* type—spike wanting, nucleus with a scar: *Voluta junonia* Hwass.
    (*c.*) *Cymba* type—nucleus enormous: *Cymba olla* L.

* "In the typical form the larva is clothed with a cuticular or horny protoconch probably similar in form to that which when shelly results in the bulbous nucleus of the other line of descent. Later on, but while still in the ovicapsule, the deposition of limy matter begins as a slender cone or elevated point along the line of the axis of the protoconch, and as the larva grows the posterior part of the mantle secretes a shelly dome." The horny protoconch, being thus cut off, disintegrates, and the apex of the shell "presents a slightly irregular dome, with a slender point rising from the apical part. . . . In some other forms the elevated point is almost or entirely wanting"; and in a third group "the nucleus is enormous but apparently secondary to a protoconch."—(Dall, 1890, pp. 67, 68.)

Cossmann (1899) criticized this method of relying on the nature of the protoconch alone for fundamental divisions, and proposed six subfamilies—Volutinae, Homoeoplocinae, Cymbinae, Zidoninae, Volutobulbinae, and Loxoplocinae—based on the sum of the shell-characters.

These proposals were not followed by Dall in his *Revision of the American Volutidae* (1907), where he used the subfamily divisions Volutinae and Caricellinae (*Scaphella* had been dropped, for reasons shown below). In a recent paper on the value of nuclear characters (1924) he has given reasons for discounting the importance which he and many others formerly attached to the protoconch as a means of classification. This does not, however, preclude its use for a particular family, and in the Volutidae nuclear characters when considered broadly seem to possess considerable significance. In New Zealand, at all events, the nuclei are remarkably constant in shells which agree closely in other characters. As might be expected, there are considerable differences in detail of the scars left by the horny protoconchs, caused by slight differences in the actual time at which the calcareous matter began to be deposited. But, apart from this, the general nature of the nucleus is a valuable guide to the systematic position of the shell.

The Volutidae of New Zealand belong almost wholly to Dall's Caricellinae, the only exceptions being *Notoplejona* (two species) and *Lyria* (one species). There is no trace of the large trochoid shelly nucleus belonging to the typical *Voluta* (*V. musica* Linné), *Amoria* (*V. undulata* Lamk.), and *Cymbiola* (*V. vespertilio* Linné). These are common along the east coast of Australia, and extend to New Guinea, Solomon Islands, and New Caledonia; but they do not seem to have reached any farther east.

2. PREVIOUS CLASSIFICATIONS.

The following table shows the different genera and some of the typical species recognized by Suter in New Zealand:—

Specific Name.	Suter, 1914.	Suter, 1917.	Suter, 1918.
arabica Martyn ..	*Fulguraria* .. .. Subgen. *Alcithoe* ..	*Fulgoraria* .. *Alcithoe* ..	*Fulgoraria.* *Alcithoe.*
attenuata Hutton ..	*Fulguraria.* Subgen. *Alcithoe* ..	*Scaphella* ..	*Maculopeplum.*
gracilicostata Zittel ..	*Volutospina.* Subgen. *Volutocorbis*	(?) *Athleta* ..	*Plejona.*
huttoni Suter ..	*Volutospina.* Subgen. *Athleta* ..	*Athleta* ..	*Plejona.*
corrugata Hutton ..	*Lapparia*	*Cymbiola* .. Subgen. *Miomelon.*	*Miomelon.*
hebes Hutton ..	..	*Lapparia* ..	*Lapparia.*
elegantissima Suter ..	..	*Scaphella* ..	*Maculopeplum.*

Alcithoe Adams, 1858.

The common *Voluta arabica* (Martyn) (*V. pacifica* Solander) is the genotype of *Alcithoe.* Important features of the shell are—

(1.) The secondary, scaphelloid nucleus.

(2.) The 4 or 5 strong oblique columellar plaits, sometimes ranging up to 6 or 7, but never below 4 even in the brephic stage.

(3.) The deep and broad anterior notch of the aperture causing a prominent fasciole.

(4.) The dilated aperture and reflexed lip of the type species.

The nuclei of Recent beach specimens are nearly always damaged, but very fine specimens—mostly of the closely related *A. swainsoni* Marwick (= *elongata* Swainson)—can be obtained from the Upper Pliocene sands of Castlecliff, Wanganui.

As can be seen, these exhibit considerable variation in shape, especially in the height of the blunt point. There can be no doubt that this shelly apex represents the stage which follows a horny protoconch, and which was named by Dall "scaphelloid."

The specimen illustrated in text-fig. 1*d* shows an abnormal condition. The walls of the bulbous top are 0·5 mm. thick, and the chamber is continuous with that of the shell. Apart from this, there are no signs of irregularity in the growth of the specimen.

The nucleus of *A. gracilis* resembles that of *A. arabica* except that it is somewhat flatter.

Harris (1897, p. 113), dealing with fossil material, recognized these features and classed both species under *Scaphella*, doubtfully including in the same genus *V. ancilloides* Tate from South Australia. He stated that his single specimen of the latter shell was without its protoconch, which according to Tate appeared to be bulbous, and therefore the generic position might be nearer *Fulgoraria*.

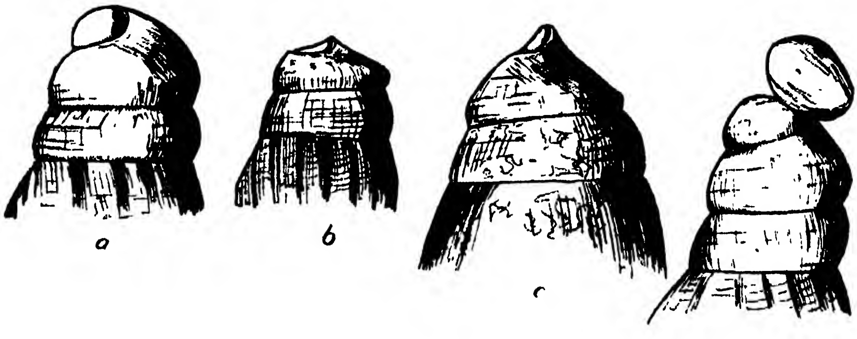


FIG. 1.—*Alcithoe swainsoni* n. sp. Apices of specimens from the Pliocene of Castlecliff. × 5.

Hedley (1906, p. 49), in pointing out the priority of *V. arabica* over *V. pacifica*, also placed the species under *Scaphella*. Later (1914, p. 725) he granted *Alcithoe* generic rank, noted its close relationship to *Adelomelon*, and stated that records of Australian occurrences were incorrect.

When Cossmann revised the family he apparently did not have access to specimens of the genotype of *Alcithoe*, for he compiled his diagnosis (1899, p. 132) from two South Australian species, *V. fulgetrum* Sowerby (Recent) and *V. ancilloides* Tate (Janjukian), neither of which is closely related to *V. arabica*. As a result he described the protoconch as bulbous, larger than the first whorls of the spire, and sometimes ornamented with ribs. He also gave a figure of the laterally rolled protoconch of *V. ancilloides*, and placed *Alcithoe* as a subgenus of *Fulgoraria*. This example was followed by Suter, who dealt mostly with Recent shells and did not notice the true nature of the apex of *V. arabica* as shown by the well-preserved fossil specimens.

The genus *Fulgoraria* Schumacher is founded on a rare shell, *V. rupestris* Gmelin, which, in addition to the lateral bulbous protoconch, has a rather attenuated anterior canal which is not notched. Other distinctive features

are a convex, thickened, not reflexed outer lip with some crenulations, and a columella furnished with from 6 to 10 folds. Thus, although the shape and ornamentation of *V. arabica* resemble those of *V. rupestris*, the important differences of protoconch and aperture show that *Alcithoe* is far removed from *Fulgoraria*.

PLEJONA Bolten, 1798.

Suter correctly perceived the affinities of his *Athleta necopinata*, although his material was exceedingly poor. Fine specimens collected by Mr. R. S. Allan at the type locality show, however, that important differences make it impossible satisfactorily to class this species under either *Athleta* or *Plejona*. From *Athleta* it differs in having one strong anterior fold and several weak posterior ones, all oblique and situated on a pad in the adult; in having a spur on the outer lip opposite the upper row of spines; and in the different disposition of the parietal callus-pad. The columella of immature specimens is like that of *Plejona*, but in the adult the folds are situated on a thick pad of callus, and the outer lip is thickened, reflexed, and crenulated. From both it differs in having a double row of spines on the whorls, as in *Neoathleta*, but it is distinguished from all these by the deep anterior notch to the aperture, forming a well-defined fasciole much stronger than that of *Athleta*. Consequently a new generic division is required, and *Notoplejona* is proposed, with *Athleta necopinata* Suter as type.

Suter's recognition of the subgenus *Volutocorbis* was probably due to Zittel's comparison of his species *V. gracilicostata* (1864, p. 39) with *V. abyssicola* Ad. & Rve., a Recent shell which was placed under *Volutocorbis* by Dall. The New Zealand shell in question is, however, not a Volute, but belongs to a common Tertiary group of Turrids for which the new genus *Austrotoma* has been proposed by Finlay (1924, p. 515). The relationship of *V. gracilicostata* to this group was also noticed several years ago by the late Mr. R. Murdoch.

The shell described by Suter (1917, p. 19) under the name of *Galeodes maoriana* does not belong to that genus, but is a Volute. Indeed, Suter himself (1915, p. 32) classed a specimen of it from Kakahu, the type locality, as *Volutospina (Athleta) huttoni* var. *pseudorarispina*. The resemblance to *Athleta rarispina* Lamk. is due to parallelism. The tendency of the body-whorl to embrace preceding whorls and to develop thick callus at the suture is quite a common gerontism in several widely-separated families—*e.g.*, *Cominella carinata* (Hutton), *Uber percrassus* (Finlay), *Baryspira robusta* (Marwick).

The apex of "*Galeodes*" *maoriana* has not been completely preserved in any of the available specimens. The protoconch was certainly quite small, but there is no direct evidence as to whether it was scaphelloid or not. On the first conch-whorls the angulation was probably well above the suture, but no specimens show this clearly. Fig. 2*a* shows a specimen in which part of the shell-substance has been removed. The neanic shell is almost biconic, with a flat or slightly concave sloping shoulder, the angle armed with strong tubercles, which extend axially well down on the convex, quickly contracting body. On about the third whorl the suture follows the line of these tubercles, which soon become shorter, so that the shell now represents the adult stage of "*Fulgoraria*" *biconica* Suter. For perhaps a quarter-volution the tubercles are obsolete and the shell is almost regularly rounded, but the suture meanwhile has been climbing slightly above the periphery, so that when the tubercles again become stronger they are well below the line of suture. On the body-whorl a thick callus is

deposited in the posterior end of the aperture, so that the shell has to curve over quickly to the suture; also, the row of sharp tubercles which are not axially elongated has shifted farther forward until it is much nearer to the anterior end of the whorl than to the posterior. On the last half-turn or so the apertural callus has become so thick that the side of the body-whorl fails to reach the penultimate whorl, so the suture is occupied by callus.

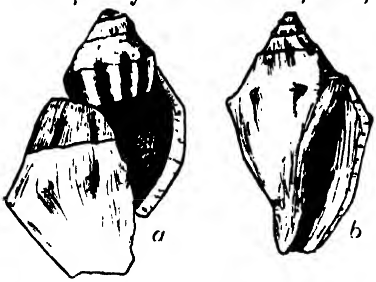


FIG. 2.—*a. Mauia maoriana* (Sut.), showing stages in ontogeny; × 2. *b. Mauia huttoni* (Sut.), juvenile; natural size.

Suter's *Volutospina huttoni* has a similar life-history, though in this case the posterior apertural callus is not so well developed; the row of tubercles does not shift anteriorly, and at very early stages the tubercles can be seen well above the suture. The supposed protoconch of *V. huttoni* var. *pseudorarispina* described by Suter (1915, p. 32) is but the eroded tip.

These shells are quite distinct from *Athleta*, *Plejona*, or *Notoplejona*, as shown not only by their life-history, but also by their adult appearance. The adult columella bears always 4 strong folds, never less or more, and no wrinkles; also it is slightly twisted anteriorly, the anterior notch is very deep and forms a prominent convex fasciole which has a median ridge, spiral sculpture is quite absent, the outer lip is thin, and the callus does not spread over the body-whorl. Thus they possess rather the characters of *Alcithoe*, but are further developed. The new genus *Mauia* is therefore proposed, with "*Galeodes*" *maorianus* Suter as type.

LYRIA Gray, 1847.

The presence of an isolated but typical *Lyria* in Middle Tertiary (probably Oligocene) beds in New Zealand is rather surprising.

The present distribution of the genus, according to Tryon (1882, p. 102), is West Indies, west coast of Central America, east coast of Africa, East Indies, Australia, Tasmania, New Caledonia; while fossil species have been recorded from the Upper Senonian of India, Paleocene to Pliocene of Europe, Paleocene to Miocene of eastern North America, and Lower to Upper Tertiary of southern Australia (Cossmann, 1899, p. 144). The New Zealand species almost certainly came from the north, for no record of the genus or any near relative has been made from South America or Antarctica. The Australian fossil species *L. harpularia* Tate and *L. gemmata* Tate are not closely related, for they appear to belong to the section *Harpeola* Dall, which has a channelled suture, on the rim of which the ribs are raised into tubercles. As far as one can judge by figures, the Parisian Eocene *L. harpula* Lamk. is the most closely related known species; it is, however, much more slender.

MACULOPEPLUM Dall, 1906.

The history of the generic names *Cymbiola* and *Maculopeplum* is rather an involved one. In his paper on the Mollusca of the "Blake" Expedition, Dall (1889, p. 147) discussed the original *Scaphella* and *Cymbiola*, pointing out Swainson's peculiar conception of what a "type" was: "In one place *V. ancilla* is cited with a query as to whether this is the type or not; at another place the author queries whether *V. ancilla* should not form a separate division, and on the same page refers to *V. vespertilio* as the type

of the whole genus. . . . The 'best known type' also figured by Swainson for his genus *Scaphella* is the *S. undulata*."

However, in his revision of the family which appeared the following year, Dall (1890) did not pursue the matter further, but accepted the common usage of *Scaphella*, with *V. junonia* Hwass as type.

Cossmann (1899) also adopted *Scaphella*, with the same type, and classed a group of South American shells in *Cymbiola* Swainson, with *V. ancilla* Solander as type; this, too, was the customary proceeding.

As a result of further consideration of Swainson's introduction of *Scaphella* and *Cymbiola*, Dall later (1907) objected to their being based on *V. junonia* and *V. ancilla* respectively. His reasons were: "While *Voluta junonia* was included among his [*i.e.*, Swainson's] species of *Scaphella*, it is obvious to the careful student that it cannot be regarded as congeneric with the forms like *V. undulata*, which was the type of *Scaphella*, and which were later named *Amoria* by Gray; nor with the *Cymbiola* group, founded on *Voluta vespertilio*, which is the *Scapha* of Gray and *Aulica* of Adams and Crosse. Both of these groups have the shelly protoconch of the Volutinae." (Dall, 1907, p. 370.) He therefore considered new generic names necessary, and proposed *Maculopeplum* (type *V. junonia*) to replace the general use of *Scaphella*, and *Adelomelon* (type *V. ancilla*), to replace that of *Cymbiola*.

Von Ihering (1907, p. 201) did not accept these changes, because he did not have the necessary literature to verify them. Neither did they appeal to Cossmann (1909, p. 205 *et seq.*), who severely criticized Dall's action and gave a revised summary of the family. He refused to recognize *Maculopeplum* on the grounds that Hermannsen had "clearly designated *V. junonia* as type of *Scaphella* in 1845," and *Adelomelon* because "it remains to be explained to what genotype the name *Cymbiola* ought to be applied."

Hedley (1914, p. 721) also investigated the position, his results being similar to Dall's except that he gave *V. maculata* Swainson as type of *Scaphella*.

Although the question does not have a direct bearing on the revised classification of New Zealand species, it concerns the use of the term "scaphelloid protoconch," consequently the writer appealed to Mr. T. Iredale, who most kindly contributed the following:—

"*Scaphella* was proposed (as given by Hedley) in the *Zool. Illustr.* (ser. 2, vol. 2, pt. 19, pl. 87, 1832), and *Scaphella maculata* was figured; Swainson, however, stated, 'Typical species, *Scaph. undulata, junonia, maculata, zebra*. Aberrant species, *Scaph. papillaris, elongata?*' Hermannsen was within his rights in selecting (*Index Generum Malacoz.*, vol. 2, 1848, p. 423) as 'Type, *Voluta junonia* Chemn.,' especially as he gave the correct introduction of the genus as above. Hedley was therefore incorrect in naming *Scaphella maculata* as type, even though it were the figured species. *Cymbiola* was introduced at the same time and place, and the shell figured was named *Voluta vespertilio*. Swainson then wrote, 'The second or subtypical genus of the Volutes appears to be represented by this common though elegant species,' adding 'As we have deemed it advisable to employ the name of *Cymbiola* (hitherto used in a specific sense) as a generic appelation for the whole group, we trust that those who may adopt our views will hereafter distinguish the *Voluta cymbiola* of Sowerby, now in the cabinet of Mr. Broderip, by the name of *Cymbiola broderipia*.'"

The Pakaurangi shells placed under *Cymbiola* by Marshall (1918, p. 266) are not Volutes, but belong to the Mitridae, though none of the present genera fit them well.

Of the two species placed by Suter under *Scaphella*, *V. attenuata* Hutton is a much damaged internal cast not even generically recognizable. It should be omitted from our lists. *S. elegantissima* Suter is a slender shell with a high spire related to the *Alcithoe* stock, and here classed as *Waihaoia* (*Teremelon*).

AMORIA Gray, 1855.

Cossmann (1899, p. 120), under *Amoria*, gives "Pliocene—L'espèce-type dans les couches récentes de la Nouvelle-Zélande, d'après M. Geo. Harris." This is a mistake; the occurrence recorded by Harris (1897, p. 109) for *A. undulata* is "Post-Pliocene: Victoria." The genus does not occur in New Zealand.

MIOMELON Dall, 1907.

Miomelon was proposed as a section of *Adelomelon* by Dall (1907, p. 365) for a small shell, *Volutilithes philippiana* Dall, which was dredged from 677 fathoms off the south-west coast of Chile. The single known specimen is not an adult, and the apex is eroded, but a number of South American fossil species included in the genus by its author give a better idea of its characters.

Cossmann (1909, p. 214) accepted *Miomelon*, but, of course, as a section of *Cymbiola*. This was followed by Suter (1917), but in the following year he elevated *Miomelon* to generic rank. The South American species attributed to *Miomelon* often have strong spiral sculpture, and from 2 to 3 plaits, rarely a fourth weak one on the columella. The New Zealand shells such as *L. parki* classed here by Suter resemble them in shape and axial ornamentation, but have 5 or 6 plaits on the columella, not less than 4 even in the brephic stage. Excepting traces on early whorls of some specimens, spiral sculpture is wanting. *Adelomelon* has no spiral sculpture, but the columella is similar to that of *Miomelon*.

L. parki and its allies are more closely related to *Alcithoe*, having the same general form, anterior notch, and columellar plaits. The most important differences are the strongly spiked nucleus of the former, and the greater tendency to angulation and tuberculation of the ribs in the latter. The new genus *Spinomelon* is therefore proposed, with *Lapparia parki* Suter as type.

LAPPARIA Conrad, 1855.

The genus *Lapparia* is based on *V. pactilis* Conrad, a small shell with a contracted base, persistent spiral ornamentation, and a shoulder armed with sharp tubercles. A deep anterior notch to the aperture causes a prominent raised fasciole; the columella is furnished with four strong plaits decreasing anteriorly; and the nucleus is scaphelloid.

Suter (1907, p. 202) placed his species *L. parki* in this genus at the instance of Dall, who had examined the specimen. Later, when he had seen Dall's new section of *Adelomelon*—*Miomelon*—with a spiked nucleus and more elongated shape, he transferred his species to it, in the meantime having synonymized *L. parki* with *L. corrugata* (Hutton). The generic change was an improvement, but, as has been stated above, the New Zealand shells are more closely related to *Alcithoe*, and have been here given the new name of *Spinomelon*. *Adelomelon*, *Miomelon*, *Alcithoe*, and *Spinomelon* are probably offshoots from a common Antarctic ancestor of Cretaceous age.

The generic position of one of the shells supposed by Suter to be *Lapparia hebes* (Hutton), but classed below as *Alcithoe angusta* (Suter), is a different question. None of the specimens has a well-preserved nucleus, but in size, shape, axial sculpture, and apertural notch they show considerable resemblance to *Lapparia*. Spiral sculpture, however, is lacking; the columellar

plaits are less mitriform and more anterior than in *Lapparia*; and the anterior fasciole is rather more specialized. Consequently it has been classed in this paper under the new genus *Mauia*, of which it represents a very early stage.

3. NEW CLASSIFICATION.

The generic grouping here proposed for New Zealand Volutes is put forward with considerable hesitation, for other schemes could be drawn up with perhaps as weighty arguments. A statement of the principles governing this classification will, at all events, make the writer's position clearer.

(1.) The shape of the nucleus is a valuable guide in grouping related shells. Allowance must be made for exceptionally early or late calcification, but where a number of individuals can be observed a general form is apparent.

(2.) The number of columellar plaits is often variable, but there are always fairly strict limits. Thus, among the dozens of specimens of *A. gracilis* examined, only one had other than 4 plaits; in the new genus *Mauia* no variation in number was seen except in the species *M. insignis*, and hardly any in several other species: *e.g.*, *A. finlayi*. Members of *Spinomelon* have nearly always 5 or 6 folds, 4 being quite exceptional.

(3.) The anterior notch has considerable systematic value. A shallow notch is a primitive character, and deepening marks evolutionary progress.

(4.) The primitive sculpture of most of the New Zealand Volutes consists of strong, smooth, sharp axial ribs. Remains of an early spiral ornamentation are occasionally seen, but do not assume any importance. Evolution from simple axial ornamentation may follow two paths:—

(*a*.) The costae may become angled and then tubercular: *e.g.*, the line *Waihaoia allani* or *W. thomsoni—bathgatei—phymatias—dyscrita*.

(*b*.) The costae may become obsolete and the shell have a smooth surface: *e.g.*, the line *Waihaoia allani—pretiosa—cognata*.

Often a tendency is manifested to revert to axial costae or tubercles after a smooth stage has been reached: *e.g.*, *Spinomelon benitens—parki—speighti*. This is also shown in the ontogeny of large examples of *Alcithoe swainsoni*, where the penultimate whorl is smooth but the body-whorl shows a return to tubercles.

(5.) The independent orthogenetic evolution of these characters in different groups produces combinations showing a considerable degree of parallelism.

The use of five genera, in addition to *Neoplejona* and *Lyria*, is proposed: *Alcithoe*, *Mauia*, *Waihaoia*, *Metamelon*, and *Spinomelon*, the last four being new, and *Waihaoia* having the two new subgenera *Teremelon* and *Pachymelon*.

Mauia and *Waihaoia* are represented in the greensand of Kakahu and Waihao, probably Eocene; *Metamelon* and *Spinomelon* are not known until the Wharekuri greensands, perhaps Middle Oligocene; but *Alcithoe* does not appear until the Awamoan—*i.e.*, Upper Oligocene or Lower Miocene. *Mauia* is proposed for an early line of shells with a deep anterior notch and a ridged fasciole. Gerontism soon developed, and the suture ascended so high that most of the spire was ultimately embraced by the body-whorl. *Waihaoia* is founded on the small *W. allani*, which has simple axial ornamentation, a scaphelloid nucleus, 5 columellar plaits, and a quite shallow anterior sinus. With it are included other shells from a lower or equally low horizon, with more advanced sculpture and 4 plaits, but still with the shallow notch. A series from Clifden described by Finlay seems most conveniently to be classed here. *W. bathgatei* has a higher spire than *W. allani*, the axials are slightly angled, and the anterior notch is deeper; the columella, however, is the same. In *W. phymatias* the spire-whorls are as in *W. bathgatei*, but on the body-whorl the axials develop into prominent

tubercles, and the shape is rather broader; the columellar folds are only 4 in number, but the notch is no deeper than in *W. bathgatei*. *W. dyscrita* is much broadened, and the ornamentation is accelerated so that most of the whorls are tubercular; the columella has 4 plaits, and the anterior notch has not advanced any farther. This development was only an offshoot from the main stock, which, except for the shortened beak, is still much the same as the Eocene *W. thomsoni* in the Miocene *W. obsoleta*.

The new subgenera *Pachymelon* and *Teremelon* are proposed for specialized groups; the former have a thick test and a fairly shallow notch; the latter are thin and graceful, for the most part smooth and shining, notch moderate, fasciole not strongly marked. These subgenera, especially *Pachymelon*, show considerable likeness to *Spinomelon*, but they have not the spiked nucleus, therefore they have been retained under *Waihaoia*.

Spinomelon (type *Lapparia parki*) has been introduced for a number of large shells of oval shape with axial corrugations, a spiked nucleus, 5 or 6 columellar folds, and a moderate to fairly deep anterior notch. The sculpture and the columellar folds are the same as in *Waihaoia allani*—indeed, the general appearance of the two species is so similar that one is almost forced to the conclusion that they are directly related.

The species grouped under *Metamelon* have also a spiked nucleus, but they are small shells inclined to gerontism, and are known as early as *Spinomelon*. The beak is always produced, the anterior notch very deep, and the base of the body-whorl contracted.

The origin of *Alcithoe*, the only living genus, is not clear. The small *Mauia angusta* has many of the characters of *Alcithoe*, but has a rather better developed anterior notch, and the protoconch is not known. *Spinomelon* is a close relative, but whether each is an independent offshoot of *Waihaoia*, whether *Spinomelon* gave rise to *Alcitho* or whether the origins are from other stocks than at present known, are difficult questions. Each has something in its favour.

4. STRATIGRAPHICAL RESULTS.

As in previous papers by the writer, the table of stratigraphical ranges has no claims to completeness. The stage divisions of our Tertiary strata are somewhat in a state of flux at present, and will be, no doubt, for some time. This is due to the increasing knowledge of some of the faunas; but we have still a long way to go before the relative time values of the different stages are accurately known. The European time scale of the table is only a rough approximation.

In this paper the Bortonian includes the Black Point sandstone (type locality), the Waihao greensands and "Island sandstone," the Kakahu greensands, and the Hampden beds. This extensive series has been subdivided by Mr. R. S. Allan, whose paper will soon be available. The Waiarekan has been omitted as there are no Volutes to list from it, restricted. The Wharekuri greensands are correlated with the Ototaran at a guess; and the Clifden beds are provisionally placed with the Hutchinsonian, pending further information from Mr. H. J. Finlay's studies on the Southland faunas. The Kai Iwi beds have been separated from the Castlecliffian, as a preliminary survey indicates that a useful stage may be recognizable between the Nukumaruan and Castlecliffian.

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APPROXIMATE RANGE OF SPECIES.

	Eocene.		Oligocene.		Miocene.				Pliocene.				
—	Wangaloan.	Bortonian.	Ototaran.	Hutchinsonian.	Awamoan.	Mokau Beds.	Tongaporutuan.	Urenui Beds.	Waitotaran.	Nukumaruan.	Kai Iwi Beds.	Castlecliffian.	Recent.
Notoplejona lata ..	—												
—— *necopinata* ..		—											
Lyria zelandica ..				—									
Mauia angusta ..		—											
—— n. sp. cf. *angusta*	—												
—— *biconica* ..		—											
—— *curvispina* ..		—											
—— *maoriana* ..		—											
—— *huttoni* ..					?								
—— *insignis* ..									?				
Waihaoia thomsoni ..		—											
—— *suteri* ..		—											
—— *superstes* ..						—							
—— *confusa* ..		—											
—— *allani* ..		—											
—— *regularis* ..				—									
—— *rugosa* ..							—						
—— *bathgatei* ..				—									
—— *phymatias* ..				—									
—— *dyscrita* ..				—									
—— *aculeata* ..					—								
—— *scitula* ..					—								
—— *tumidior* ..				—									
—— *elegantissima* ..					—								
—— *awamoaensis* ..					—								
—— *pretiosa* ..				—									
—— *cognata* ..					—								
—— *waitakiensis* ..			—										
—— *murdochi* ..					—								
—— *amoriaformis* ..					—								
—— *firma*					—								
—— *lutea*													—
Spinomelon enysi ..					—								
—— *benitens* ..				—									
—— *parki* ..					—								
—— *speightii* ..					—								
—— *mira*					—								
Metamelon inermis ..				—									
—— *marshalli* ..			—										
—— *clifdenensis* ..				—									
—— *reverta* ..					—								
—— *minima* ..				—									

APPROXIMATE RANGE OF SPECIES—*continued.*

—	Eocene.		Oligocene.		Miocene.				Pliocene.				
	Wangaloan.	Bortonian.	Ototaran.	Hutchinsonian.	Awamoan.	Mokau Beds.	Tongaporutuan.	Urenui Beds.	Waitotaran.	Nukumaruan.	Kai Iwi Beds.	Castlecliffian.	Recent.
Alcithoe turrita ..				—									
—— *wekaensis* ..					—								
—— *detrita* ..										—			
—— *nukumaruensis*										—			
—— *cylindrica* ..					—								
—— *compressa* ..					—								
—— *armigera* ..					—								
—— *robusta* ..					—								
—— *sequax* ..					—								
—— *familiaris* ..					—								
—— *irregularis* ..						?							
—— *hurupiensis* ..							?						
—— *arabicula* ..									—				
—— *lutea*										—			
—— *transformis* ..											—		
—— *swainsoni* ..											—	—	—
—— *larochei* ..												?	—
—— *arabica* ..												—	—
—— *acuta*												—	
—— *oliveri* ..										?			
—— *depressa* ..												—	—
—— *jaculoides* ..													—
—— *lepida* ..					—								
—— *reflexa* ..					—								
—— *finlayi* ..					—								
—— *scopi*					—								
—— *neglecta* ..					—								
—— *solida* ..							?	—					
—— *exigua* ..										—	—		
—— *brevis* ..										?			
—— *subgracilis* ..										—			
—— *mackayi* ..										—			
—— *gracilis* ..										—	—	—	—
—— *hedleyi* ..													—
—— *dilatata* ..							?						
—— *parva* ..									—				
—— *residua* ..				—									
—— *gatesi* ..									—				
—— *haweraensis* ..									—				
—— *whakinoensis* ..									—				

5. SYSTEMATIC CLASSIFICATION AND DESCRIPTIONS.

Synopsis of Genera and Subgenera.

1. *Notoplejona:* Small, fusiform; spire low; protoconch small, shelly; each axial rib with 2 spines, spiral ornamentation strong anteriorly; thick pad of callus on body; anterior notch strong; columella with 1 strong fold and several wrinkles; in adults these are situated on a pad.
2. *Lyria:* Small, oval; spire low; protoconch small, shelly; strong axial ribs, anterior notch moderate, columella with 2 strong anterior folds and several weak wrinkles above them.
3. *Mauia:* Broadly fusiform; protoconch uncertain; armed with tubercles sometimes extended into axials; anterior notch very deep, fasciole ridged, columella with 4 strong, narrow folds.
4. *Waihaoia:*—
   (a.) (*Waihaoia*): Small, narrowly fusiform; spire high; nucleus scaphelloid; axially ribbed, often developing tubercles; anterior sinus shallow, almost absent, fasciole inconspicuous or absent, columella with 4 or 5 folds.
   (b.) (*Teremelon*): Small, narrowly fusiform, spire high; nucleus small, scaphelloid; first few whorls axially ribbed, remainder smooth and polished; anterior notch moderate, not making a prominent fasciole; columella with 5 narrow folds in typical group, 4 in "*cognata*" group.
   (c.) (*Pachymelon*): Small, broadly fusiform, thick and heavy, spire low, nucleus large, scaphelloid, rather globose; axial ribs becoming obsolete; anterior sinus shallow; fasciole inconspicuous; columella produced, generally with 5 folds.
5. *Spinomelon:* Large, fusiform; nucleus caricelloid with high spike; axial ribs generally becoming obsolete, rarely developing into tubercles; anterior notch moderate; fasciole conspicuous, columella produced, generally with 5 or 6 folds.
6. *Metamelon:* Small, broadly fusiform; nucleus small, caricelloid with sharp spike; spire-whorls smooth, body-whorl inflated, constricted below, generally with long axial ribs, fasciole exceedingly well marked; anterior notch deep; columella with 5 folds.
7. *Alcithoe:* Generally large, fusiform; nucleus scaphelloid; axial ribs generally developing into tubercles or nodules; anterior notch deep, fasciole well marked; columella with 4 or 5 folds, sometimes more.

1. Notoplejona n. gen.

Shell rather small, fusiform. Spire turreted. Fasciole well marked. Sculpture of strong axial ribs bearing double row of spines, one below suture, one on periphery; whole whorl with spiral lirae often stronger anteriorly. Aperture deeply sinused next suture and deeply notched below. Outer lip thickened, reflexed, crenulated, sharply angled where sutural row of tubercles abuts. Columella convex with 4 or 5 weak posterior oblique folds and a stronger spaced anterior one. Inner lip with a thick callus-pad.

Type: *Athleta necopinata* Suter.

Notoplejona necopinata (Suter). (Plate 66, figs. 2, 5.)

1917. *Athleta necopinata* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 40, pl. 5, fig. 7.
1918. *Plejona necopinata* (Suter), *Alph. List N.Z. Tert. Moll.*, p. 23.

Owing to faulty material, Suter's description of the columella is not correct. On very early whorls there is but one strong plait, well down on the columella; later a second weak one appears posteriorly, and afterwards three others (sometimes more) in succession; the posterior plaits are grouped together, remain much weaker than the anterior one, and the columella is straight until the adult stage is reached. Here the four weak plaits are gathered on to a strong callus-pad, which extends to the anterior plait and tends to obliterate it. The protoconch is not preserved in any of the specimens, but it was evidently quite small.

Localities.—Greensand, Waihao Downs (type); 480, "Island sandstone," Waihao River; 164, Greensand, Kakahu; 176, Black Point.

Notoplejona lata n. sp. (Plate 66, fig. 1.)

Shell rather small, broadly fusiform. Spire turreted, about one-third height of aperture. Body-whorl with sloping concave shoulder, below which it contracts slowly at first, then quickly, finally straightening again; anterior with well-marked fasciole, bounded above by low broad ridge. Suture deeply impressed. Sculpture of 10 broad low axial ribs with wide interspaces, ribs extending almost to fasciole; on periphery of shoulder, also below suture, are strong tubercles; whole surface with numerous, undulating, spaced, bevelled, spiral lirae, weak over greater part of body, slightly stronger on shoulder, much stronger on anterior constricted part of whorl. Aperture with subparallel sides, deeply notched anteriorly. Outer lip thickened and reflexed, slightly crenulated. Columella strongly convex in adult, with about 5 weak folds, anterior one separated by wider interspace than others. Inner lip with a thick pad of callus burying but not obliterating spines and extending to suture.

Holotype in collection of New Zealand Geological Survey.

Height, 26 mm.; diameter, 14 mm.

Locality.—759, Castle Hill shaft, Kaitangata.

Easily distinguished from *N. necopinata* by lower spire and more squat shape.

2. LYRIA GRAY, 1847.

Shell rather small, ovoid, thick. Spire conical. Body-whorl regularly convex; fasciole well marked. Sculpture of strong axial ribs. Aperture channelled above, deeply notched below. Outer lip thickened, with an external varix. Columella with 3 almost horizontal folds, above which are several weak wrinkles.

Type: *Voluta nucleus* Lamk.

Lyria zelandica Finlay. (Plate 64, fig. 1.)

1925. *Lyria zelandica* Finlay. *Trans. N.Z. Inst.*, vol. 55, p. 470, pl. 49, fig. 7.

Locality.—Clifden, Southland, 6B.

3. MAUIA n. gen.

Shell moderate to small in size, strong, broadly fusiform. Spire generally low conic or conoid. Protoconch unknown but small. Body-whorl large, often embracing most of the previous whorls, contracting quickly to the neck; fasciole large, convex, projecting, bounded above by a sharp ridge and with another rounded central ridge. Suture sometimes filled with callus, which forms a thick parietal pad. Sculpture of sharp tubercles which are represented by axial ribs on primitive species, on advanced ones the row of tubercles is far forward on shell. Aperture broad, deeply notched below. Outer lip thin, simple. Columella with 4 strong plaits.

Type: *Galeodes maoriana* Suter.

SYNOPSIS OF SPECIES.

A. Small to moderate size (under 80 mm.).
- 1. Tubercles stronger than axials.
  - (*a*.) Spire turreted .. .. *angusta*.
  - (*b*.) Spire conic, tubercles short, sides of body not convex *biconica*.
  - Spire conic, tubercles long, recurved, body convex *curvispina*.
  - (*c*.) Spire immersed .. .. *maoriana*.
- 2. Axials stronger than tubercles .. .. .. *insignis*.

B. Very large (over 100 mm.).
- 1. Body-whorl embracing most of spire .. .. .. *huttoni*.

Mauia angusta (Suter). (Plate 61, figs. 4, 13.)

1917. *Galeodes (Pugilina) angusta* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 18, pl. 11, fig. 19.

Shell small, fusiform. Spire strongly gradate, not quite equal in height to aperture. Whorls broad and low, with a concave shoulder, below which body-whorl is slightly convex then contracted; anterior fasciole strongly developed, bounded above by prominent ridge, and with another broader ridge a short distance above lower boundary. Suture undulating. Sculpture of 7 long strong tubercles, which extend longitudinally as axial ribs almost to basal fasciole below, and often, though weakly, to suture above. Aperture oblong, angled above, with deep anterior notch. Outer lip thin, straight. Columella with 4 rather weak folds, anterior two close together.

Holotype and lectotype in collection of New Zealand Geological Survey.

Locality.—164, greensand, Kakahu.

The type specimen of *Galeodes angusta* is an internal cast, but it clearly belongs to the same species as a number of strongly ribbed Volutes which Suter classed along with two other species under his *Lapparia hebes* (Hutton).

Satisfactory generic placing of this shell is rather difficult. It probably represents the ancestral type of such shells as *Mauia*, in which the suture in neanic whorls is below the periphery, and which have a similar four-plaited columella, deep anterior notch, and prominent fasciole with strong ridge bounding it above, and another strong central ridge with concave space between. It also resembles *Alcithoe*, from the typical species of which it differs not only greatly in size but also in the small nucleus and strongly-ridged fasciole. *M. angusta* may, indeed, be an ancestor of *Alcithoe*; the highly specialized siphonal fasciole probably indicates that it is not on the direct line, but marks a gerontism that culminates in such forms as *M. maoriana*, and *M. huttoni*.

M. angusta, as perceived by Suter, closely resembles *Lapparia*, but the fasciole is slightly more specialized, there is no spiral sculpture, and the axials have developed along a different line, having become strong and tubercular, while those of *Lapparia* develop into spines something like those of *M. maoriana*. Unfortunately, none of the specimens shows a complete apex.

What is probably a related species, though much more slender, occurs at locality 759, Castle Hill shaft, Kaitangata. The single specimen is incomplete, and is mostly an internal cast, so one cannot be certain about it.

Mauia biconica (Suter). (Plate 61, fig. 15.)

1917. *Galeodes biconica* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 18, pl. 11, fig. 20.
1917. *Fulgoraria (Alcithoe) biconica* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 39, pl. 5, figs. 5, 6.

Curiously enough, Suter gave the same specific name to the two shells listed above. The one which he called *Galeodes biconica* has 4 strong plaits on the pillar and so is certainly not a *Galeodes* (= *Melongena*); it agrees, however, in all particulars except size with the type of *Fulgoraria biconica*. *Galeodes biconica* has page priority, so the small shell becomes the type of the species. One of Suter's plesiotypes of *Lapparia hebes* (Hutton) is a *M. biconica* (Suter, 1917, p. 41, pl. 12, fig. 11.) Sometimes it is difficult to decide whether young shells are *M. biconica* or *M. maoriana*, as the latter passes through a stage represented by the former.

Localities.—Greensand, Kakahu (type); greensand, Waihao Downs; Hampden.

Mauia curvispina n. sp. (Plate 69, fig. 13.)

Shell large, solid. Spire low, conic, one-quarter height of aperture. Spire-whorls slightly concave; body-whorl with long steep slightly convex shoulder, which is strongly tubercular on the periphery, below which whorl contracts very slowly at first then rather quickly to a huge fasciole bounded above by high narrow ridge and traversed by strong median rounded ridge. Sculpture: periphery armed with 10 tubercles, at first low and sharp, but increasing rapidly in strength so that later ones are long and strongly curved posteriorly. Suture undulating, situated a little above line of tubercles and on last half-whorl filled with callus. Aperture fairly large, very deeply and rather narrowly notched below. Outer lip broken but apparently rounded, not reflexed, and strongly convex. Columella with 4 high, narrow, spaced plaits. Inner lip fairly well spread as a thin glaze, forming a moderate pad on the parietal wall.

Holotype in collection of New Zealand Geological Survey, deposited by Mr. R. S. Allan.

Height, 72 mm.; diameter, 45 mm.

Locality.—Greensand, Waihao Downs.

This species represents an advance from *M. biconica*, marked by convexity of the body-whorl, and the development of long recurved spines.

Mauia maoriana (Suter). (Plate 61, fig. 9; and text-fig. 2*a*.)

1917. *Galeodes maoriana* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 19, pl. 3, fig. 11.

The resistant matrix having been cleared from the aperture of the holotype, the columella displays 4 strong oblique folds, the anterior one weaker than the others. This with the deep anterior notch shows that the shell is a Volute, not a *Galeodes* (= *Melongena*). A description of the ontogeny and relationship to *Mauia biconica* (Suter) is given above (p. 262). The embracing, rounded body-whorl, calloused suture, and anteriorly placed tubercles are all gerontic features.

Locality.—164, greensand, Kakahu.

Mauia huttoni (Suter). (Plate 61, fig. 8.)

1873. *Voluta kirki* Hutton, *Cat. Tert. Moll.*, p. 7 (not of Hutton, *Cat. Mar. Moll.*).
1914. *Volutospina (Athleta) huttoni* Suter, *N.Z. Geol. Surv. Pal. Bull. 2*, p. 26, pl. 16, figs. 3 *a*, *b*.
1917. *Athleta huttoni* (Suter), *N.Z. Geol. Surv. Pal. Bull. 5*, p. 87.
1918. *Plejona huttoni* (Suter), *Alph. List. N.Z. Tert. Moll.*, p. 23.

The shell (fig. 2*b*) listed from Mount Harris as *Fulgoraria biconica* (Suter, 1921, p. 64) is not that species, for it has a more contracted convex body and a longer neck; but it agrees exactly with the apex of well-preserved specimens of *Mauia huttoni*, and can be regarded with practical certainty as the young of that species. The preservation and adhering matrix are not like those of Mount Harris, but are identical with some of the fossils from Trelissick Basin, locality 451A, Pareora beds, junction of Porter and Thomas Rivers. Although the locality-label now reads 475, the 7 has been put on with different ink at a much later date over an original 5. Locality 455 was supposed to be from the Triassic of Okuku, but in a manuscript copy of fossiliferous locality descriptions written by McKay the following note appears: "This collection is wrongly numbered, as 455 is a numerous collection of Miocene fossils either from Pareora River Valley or the Thomas River, Trelissick Basin."

Locality.—Broken River, Trelissick Basin.

Mauia pseudorarispina (Suter).

1915. *Volutospina (Athleta) huttoni pseudorarispina* Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 31, pl. 5, fig. 6.
1917. *Athleta huttoni pseudorarispina* (Suter), *N.Z. Geol. Surv. Pal. Bull. 5*, p. 87.
1918. *Plejona huttoni pseudorarispina* (Suter), *Alph. List N.Z. Tert. Moll.*, p. 23.

The value of this species or variety is uncertain. The shape of *M. huttoni* varies considerably according to the amount of callus below the suture, coupled with the degree of submersion the spire has undergone. Individual differences are so great that it is extremely doubtful whether *M. pseudorarispina* represents a constant group. Also, further collecting is required to ascertain if any stratigraphical significance appertains to the respective forms.

Localities.—Broken River, Trelissick Basin; Porter River, Trelissick Basin.

The shell recorded under this heading from Kakahu by Suter (1915, p. 32) is a damaged example of *Mauia maoriana*.

Mauia insignis n. sp. (Plate 61, fig. 14.)

Shell of moderate size, unequally biconic. Spire gradate, one-fourth height of aperture. Nucleus eroded but probably scaphelloid. Post-embryonic whorls about 4, concave on spire; body with rather narrow but deeply concave steep shoulder, prominently angled at periphery, below which body contracts slowly and regularly to very prominent fasciole bounded by ridge, concave along outer half and with another broadly rounded ridge forming inner half. Sculpture of 20 or more strong sharply raised axial ribs with wider interstices, extending from suture to suture and almost down to fasciole, before reaching which they weaken and bend quickly off to right; ribs are slightly but sharply tuberculate on periphery. Suture strongly impressed, just below line of tubercles. Aperture long and narrow, channelled above, deeply notched below. Outer lip broken but evidently thickened, slightly reflexed, and ascending above the periphery. Columella padded within, with 4 strong, rather narrow, spaced plaits and a fifth low broad rounded posterior one. Inner lip not much expanded, thin above, thicker below, and forming with rounded ridge of fasciole deep narrow furrow.

Holotype in Canterbury Museum.

Height, 51 mm.; diameter, 23 mm.

Locality.—Dovedale, coast between Waipara and Motunau Rivers (probably from Pliocene beds, in the opinion of Professor R. Speight).

This distinctive species has no close relative in our collections, but seems to be a development of *M. biconica* along lines of increase in number and extension of the axials.

4. Waihaoia n. gen.

Shell rather small, fusiform. Nucleus scaphelloid. Fasciole absent or ill-defined. Sculpture of axial ribs sometimes developing to strong tubercles, sometimes disappearing at an early stage. Aperture with a shallow to moderate anterior sinus. Columella with 4 or 5 plaits.

Type: *Waihaoia allani* Marwick.

(A.) Waihaoia n. subgen.

Shell rather small, fusiform. Spire nearly as high as aperture. Nucleus scaphelloid, of 2 or 3 smooth whorls. Body-whorl contracting gradually;

fasciole absent. Sculpture of axial ribs indistinctly angled to tubercular. Aperture with a very shallow anterior sinus. Outer lip simple, thin or slightly thickened. Columella of type with 5 strong plaits on a convex pad; some species have only 4.

SYNOPSIS OF SPECIES.

A. Axial ribs only.
  1. Narrowly fusiform .. .. *allani.*
  2. Broadly fusiform, spire gradate .. .. *rugosa.*
     Broadly fusiform, spire conic .. .. *regularis.*
B. Axial ribs on spire, but later disappearing .. .. *scitula.*
C. Axial ribs on spire, but later becoming slightly tubercular.
  1. Shell very narrow, anterior end long, 9 axials .. .. *thomsoni.*
  2. Anterior end short, tubercles sharp, 12 axials .. .. *bathgatei.*
  3. Tubercles blunt, 8-12 .. .. *superstes.*
D. Axial ribs on spire, but later becoming strongly tubercular.
  1. Anterior end long, tubercles moderate .. .. .. *suteri.*
  2. Anterior end short, tubercles very strong .. .. .. *phymatias.*
E. Strongly tubercular on both spire and body.
  1. Sharp tubercles nearer anterior suture .. .. .. *aculeata.*
  2. Rather blunt tubercles nearer posterior suture .. .. *confusa.*
  3. Shell very broad, nucleus flat .. .. *dyscrita.*

Waihaoia allani n. sp. (Plate 61, fig. 5.)

Shell small, fusiform. Spire conic, about as high as aperture Nucleus scaphelloid, of about 3 smooth whorls. Post-embryonic whorls 4½, at first convex, then bluntly angled about middle; body-whorl with short steep shoulder, below which it is straightened, then moderately contracted; fasciole not marked. Sculpture: spire-whorls with 12, body-whorl with 14, strong axial ribs, bluntly angled on shoulder and twisted backward, interstices equal or slightly wider; on spire, ribs extend from suture to suture and well down on body-whorl. Aperture moderate, angled above with extremely shallow sinus below. Outer lip thick, not reflexed, slightly convex, a little ascending. Columella with pad bearing 5 strong folds, anterior weakest. Outer lip with thin glaze.

Holotype in Dominion Museum.

Height, 45·5 mm.; diameter, 16 mm.

Locality.—Greensand, McCullough's Bridge, Waihao River.

The nucleus of the holotype is not normal, having the appearance of being unrolled.

Waihaoia regularis (Finlay). (Plate 61, fig. 6.)

1926. *Alcithoe regularis* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 247, pl. 55, fig. 4.

In general appearance this shell resembles *M. clifdenensis*; but if any reliance can be placed on recapitulation as shown by ornamentation, &c., the relationship is not so close as at first glance appears. The post-embryonic whorls are strongly axially ribbed from suture to suture right from the neanic stage, whereas ribs do not appear in *M. clifdenensis* until the penultimate whorl. Also, the anterior notch in *W. regularis* is not so deep nor the fasciole so well defined. Further, although the nucleus is damaged, enough remains to show, in the writer's opinion, that it had a flattened top, as in the *W. bathgatei* group. The shallow anterior notch agrees with this systematic position. *W. regularis* represents a broadened offshoot from *W. bathgatei*, or earlier, for the sculpture is of simple axial ribs throughout.

Locality.—Clifden (band 8).

Waihaoia bathgatei (Finlay). (Plate 61, fig. 7.)

1926. *Alcithoe bathgatei* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 248, pl. 56, figs. 4, 5.

The spire is about equal in height to aperture, and the whorls have each about 16 narrow ribs with wide concave interspaces. The ribs soon become angled, and finally short sharp tubercles are developed, but the ribs still extend to the suture above and well down over the body-whorl. The anterior notch is rather shallow, and on some specimens the fasciole is quite convex, it is not rough nor bounded by a ridge; the columella has 4 folds, decreasing anteriorly; sometimes a fifth weak fold appears posteriorly. The apex of the nucleus is generally flattened, but occasionally somewhat domed.

This species seems to be a development from such forms as *W. suteri*, the anterior end of the shell having shortened considerably and the notch become slightly deeper.

Locality.—Clifden, Southland (bands 4, 6A).

Waihaoia phymatias (Finlay). (Plate 61, fig. 11.)

1926. *Alcithoe phymatias* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 248, pl. 56, figs. 1–3.

This shell is a descendant of *W. bathgatei* in which the tubercles on the shoulder have greatly enlarged, with a consequent loss of the axial ribs, the *bathgatei* stage being represented about the fourth conch-whorl. The anterior notch is still shallow, and the fasciole is not marked off from the base of the body-whorl. The nucleus is somewhat larger, and is a little more flattened on the summit.

Locality.—Clifden (band 6B).

Waihaoia dyscrita (Finlay). (Plate 61, fig. 12.)

1926. *Alcithoe dyscrita* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 249, pl. 55, fig. 9.

An accelerated offshoot from *W. phymatias* in which the height has greatly decreased compared with the diameter. The top of the nucleus is broken in the single specimen found, but there is little doubt that it was the same as that of *A. phymatias*. Further points of agreement are the columella with 4 mitriform folds, and the shallow anterior notch not forming a well-defined fasciole. Only the first 2 or 3 axials are without a tubercle, so that the ancestral ornamentation, occupying 2 or 3 whorls in *W. bathgatei* and *W. suteri* and 1 whorl in *W. phymatias*, has almost disappeared.

y.—Clifden (band 6C).

Waihaoia confusa n. sp. (Plate 61, fig. 3.)

1917. *Lapparia hebes* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 40 (in part, but not of Hutton), pl. 12, fig. 12.

Shell somewhat small, elongate fusiform. Spire strongly gradate, about two-thirds height of aperture. Diameter of spire-whorls about twice their height, and with a concave shoulder; body-whorl slightly convex, very gradually contracting, with a well-marked fasciole not bounded above by a ridge. Suture undulating. Sculpture of 7 sharp tubercles on the shoulder, not produced into definite axial ribs. Aperture oblong, angled above, deeply notched below. Columella with 4 plaits, the upper 3 strong, more than equal to the interspaces, the lowest very weak.

Holotype in collection of New Zealand Geological Survey.

Height, 33 mm.; diameter, 15 mm.

Locality.—164, greensand, Kakahu.

Hutton's lost type of *Pleurotoma hebes* has now been recovered, and it shows how far Suter went astray in his selection of plesiotypes. The original shell is certainly not a Volute, but is congeneric with the shell described by Suter as *Ptychatractus nodosoliratus*. Of the two specimens figured by him as plesiotypes, one (pl. 12, fig. 11) is a *Mauia biconica*, the other (pl. 12, fig. 12) belongs to the species described above. Many specimens of another shell, *Mauia angusta* (Suter), were also identified by Suter as *Lapparia hebes*.

Lapparia, a genus from the North American Eocene, has strong spiral ornamentation reticulated by the growth-lines, and a deep anterior notch.

Waihaoia thomsoni n. sp. (Plate 61, fig. 1.)

Shell rather small, narrowly fusiform. Spire turreted, in height equal to or a little greater than aperture. Whorls 6 remaining, at first probably convex, but soon developing a sloping shoulder, on later whorls shoulder-angle gets lower until finally it is in middle of whorl, above it whorl is slightly concave and very steep; body-whorl subcylindrical for some distance below shoulder, then contracting quickly, finally slowly to a rather long neck, which is bent outwards in type but is straightened in a paratype, and bears an inconspicuous fasciole. Sculpture: spire-whorls with 9 narrowly rounded axial ribs with wide interstices, on later whorls these decrease in number and relative length and strength until on body-whorl there are only 6 obsolete knobs. Aperture long and narrow, with subparallel sides contracting to angle above; anterior sinus shallow, the effect rather increased by outward twist to canal. Outer lip broken but apparently straight, thin, not reflexed or ascending. Columella long, projecting slightly, bent outwards below, bearing 4 well-spaced folds, anterior and posterior weakest. Inner lip with well-defined outer edge.

Holotype in Dominion Museum.

Height, 52 mm.; diameter, 15 mm.

Locality.—Greensand, Waihao Downs.

Distinguished from *W. suteri* by the fewer and much weaker ribs, also by the disposition of the columellar folds.

A crushed shell from Hampden in Dr. Marshall's collection at Wanganui Museum perhaps is related to this species. It has ribs on the spire-whorls, but they are obsolete on the body. The length is about 73 mm., and the columella bears 5 plaits.

Waihaoia suteri n. sp. (Plate 61, fig. 2.)

Shell rather small, narrowly fusiform. Spire turreted, equal in height to the aperture. Nucleus damaged but apparently scaphelloid. Post-embryonic whorls 6, early ones convex but soon developing a shoulder which later becomes concave and prominent; body-whorl for a short distance below shoulder almost cylindrical, then contracting rather quickly at first but afterwards more slowly so as to produce a rather long neck which has practically no fasciole. Sculpture: early whorls with 12 narrow high axial ribs extending from suture to suture; on third whorl these ribs become angled and have a short concave shoulder; on later whorls their number is reduced to 11 and finally to 10; angulation increases in strength, and above it ribs are much weaker though they persist to suture; on body-whorl ribs extend down on to contracting base but do not reach neck. Aperture long, with subparallel sides, angled above, scarcely notched below. Outer lip broken, but apparently thin and straight, not ascending or

reflexed. Columella with 4 narrow, well-spaced plaits decreasing in strength anteriorly. Inner lip thin.

Holotype in Canterbury Museum.

Height, 50 mm.; diameter, 17 mm. (*circa*).

Locality.—Greensand, Waihao Forks.

By some mistake this specimen was figured by Suter (1915, pl. 4, fig. 14) as the holotype of *Fulguraria aculeata* (Hutton), and a wrong magnification given.

Waihaoia superstes n. sp. (Plate 61, fig. 10.)

Shell rather small, narrowly fusiform. Spire turreted, slightly less in height than aperture. Whorls 5 remaining, angled above mid-point, and with a sloping slightly concave shoulder; body-whorl straightened below shoulder, then contracting rather quickly, finally again straightening out to an inconspicuous though convex fasciole which is not definitely bounded above. Sculpture: early whorls with 14 or 15 low axial ribs which scarcely reach sutures, and which are developed into low tubercles on shoulder-angle; on later whorls axials become shorter and fewer, and tubercles stronger; on penultimate there are 12 and on body-whorl 8. Aperture long, sides subparallel, anterior sinus very shallow. Outer lip slightly convex and ascending. Columella with 4 rather weak spaced plaits. Inner lip moderate.

Holotype in collection of New Zealand Geological Survey.

Height, 44 mm.; diameter, 16 mm.

Locality.—894, Mokau River.

This shell is very like *W. thomsoni* except that the anterior end is shorter. It probably belongs to a northern stock that has descended from *W. thomsoni* independently of the Southland species *W. bathgatei*, &c., for the anterior sinus shows no sign of deepening.

This is the *Fulgoraria arabica* (Hutt.) of Suter (Henderson and Ongley, 1923, p. 36).

Waihaoia aculeata (Hutton). (Plate 64, fig. 6.)

1885. *Voluta aculeata* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 325.
1915. *Fulgoraria (Alcithoe) aculeata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 31, pl. 4, fig. 14.

The shell figured by Suter is not the holotype. The statement to this effect in the explanation of plates (Suter, 1915, p. 63) errs also in stating that the figure is "enlarged 1½ diameters." The original specimen from which the photograph was taken is in Canterbury Museum, and comes from Waihao Forks. It is described above under the name *Waihaoia suteri* n. sp. Suter's description of *W. aculeata* is, however, correct, being based on the true type specimens. Important features of the shell are the small size; straight, sharp outer lip; sharp spines on last whorls developed from strong angled axial ribs on the early whorls; shallow anterior notch which makes an inconspicuous fasciole.

The locality was given by Hutton as White Rock River, but the specimens are not from the bed usually collected from. Their matrix has a large amount of a greenish mineral that appears to be glauconite, so further collecting is needed to clear up a doubt as to the age of this species.

Waihaoia rugosa n. sp. (Plate 70, fig. 4.)

Shell of moderate size, fusiform. Spire almost as high as aperture. Whorls bluntly angled with a long sloping shoulder; body-whorl inflated,

contracted relatively quickly to the large fasciole.. Suture undulating. Sculpture of 20 strong axial ribs with equal interstices, ribs twisted and extending from suture to suture on spire and across body-whorl almost to fasciole; on spire-whorls are numerous somewhat irregular spiral lirae crossed by fine close growth-lines. Aperture with wide but shallow anterior sinus. Columella with 4 strong folds with interspaces twice their width. Inner lip extending from aperture as a thick callus.

Holotype in collection of New Zealand Geological Survey.

Height, 54 mm.; diameter, 25 mm.

Locality.—1038, Flat Trig., North Shore, Palliser Bay.

A. rugosa is probably related to *Voluta corrugata* var. B Hutton. The latter, however, is much larger, and has 5 strong folds and 1 weak one on the columella. *W. rugosa* differs from the typical *Waihaoia* in having a well-developed fasciole. The sinus which forms it, however, is fairly shallow.

Waihaoia scitula n. sp. (Plate 64, fig. 5.)

Shell small, thin, broadly fusiform. Spire turreted, one-half height of aperture. Nucleus missing. Post-embryonic whorls prominently angled about the middle, with a fairly broad concave shoulder; body-whorl for some distance cylindrical, then contracted to a short neck bearing an insignificant fasciole not bounded above. Sculpture of about 20 broad axials on early whorls reaching from suture to suture but very weak on shoulder, on penultimate whorl these become obsolete, and body-whorl is quite smooth. Aperture triangular, rather wide, narrowly channelled above, with a shallow anterior sinus. Outer lip thin, straight, not ascending or reflexed. Columella with 4 strong spaced plaits. Inner lip thin, restrained.

Holotype in Canterbury Museum.

Height, 31 mm.; diameter, 14 mm.

Locality.—Porter River, Trelissick Basin.

"*Scaphella gracilis* (Swainson)," according to Hutton's tablet. Easily distinguished from that species by the general shape, concave shoulder, and shallow anterior notch. It is not closely related to any other species so far collected.

(B.) TEREMELON n. subgen.

Shell rather small, narrowly fusiform. Spire nearly as high as aperture. Nucleus scaphelloid, rather flat. Sculpture: first one or two whorls with curved axial ribs, later whorls smooth and shining. Fasciole moderately marked, not rugose, and surface not departing from normal curve of the shell. Aperture moderately notched. Outer lip thin, straight. Columella with 5 rather narrow plaits.

Type: *Scaphella tumidior* Finlay.

The group *W. pretiosa*-*cognata* perhaps represents a line of evolution independent of the type species, which is intimately related to *W. elegantissima* and *W. awamoaensis*. The shells of the former group have a deeper anterior notch and better-marked fasciole, the ribbing advances farther down the spire, the nucleus is higher, and the columella has only 4 plaits.

SYNOPSIS OF SPECIES.

A. Columella with five plaits, ribbing scarcely developed.
- 1. Form narrow .. *elegantissima.*
- 2. Regularly fusiform *awamoaensis.*
- 3. Somewhat inflated *tumidior.*

B. Columella with 4 plaits, ribbing extended some distance down spire.
- 1. Whorls convex .. *cognata.*
- 2. Whorls flattened *pretiosa.*

Waihaoia (Teremelon) tumidior (Finlay). (Plate 62, fig. 2.)

1926. *Scaphella tumidior* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 250, pl. 56, fig. 6.

This species is wider and has a lower spire than *A. elegantissima.*

Localities.—Otiake; greensand opposite Wharekuri.

Waihaoia (Teremelon) elegantissima (Suter). (Plate 62, fig. 1.)

1917. *Scaphella elegantissima* Suter, *N.Z. Geol. Surv. Pal. Bull.* 5, p. 41, pl. 5, fig. 9.

1918. *Maculopeplum elegantissimum* (Suter), *Alph. List of N.Z. Tert. Moll.*, p. 18.

Locality.—Shell-bed below uppermost Mount Brown limestone, Weka Pass Stream.

Waihaoia (Teremelon) awamoaensis n. sp. (Plate 62, fig. 4.)

Shell rather small, narrowly fusiform. Spire conic, two-thirds height of aperture. Nucleus scaphelloid, of 2 smooth volutions. Post-embryonic whorls 5, slightly convex on spire; body-whorl with rounded shoulder, below which it is very slightly convex and contracts gradually to a fasciole which is not well marked off except for a lack of polish. Sculpture: first two whorls with 15 rather narrow axial ribs, the last ones becoming obsolete, below this the shell has a smooth polished surface covered with microscopic waved spiral lirae, crossed by numerous growth-lines. Aperture triangular, widely and fairly deeply notched below. Outer lip thin, scarcely ascending. Columella straight, furnished with 5 plaits, the anterior and posterior weakest. Inner lip spread as a thin glaze some distance from aperture.

Holotype in collection of New Zealand Geological Survey.

Height, 48 mm.; diameter, 16 mm.

Locality.—1160, blue sands, Awamoa Creek.

Intermediate in shape between *A. elegantissima* and *A. tumidior.*

Waihaoia (Teremelon) pretiosa (Finlay). (Plate 62, fig. 7.)

1926. *Scaphella pretiosa* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 250, pl. 55, figs. 7, 8.

The nucleus is large and scaphelloid; the anterior notch is moderate, just deep enough to form a slight bounding ridge, and there are only 4 mitriform folds on columella. Spire-whorls flattened, and sculpture, of about 17 narrow axial ribs with concave interstices, becomes obsolete on body-whorl.

Locality.—Clifden (band 6A).

Waihaoia (Teremelon) cognata (Finlay). (Plate 62, fig. 5.)

1926. *Scaphella cognata* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 249, pl. 56, fig. 7.

In this species the shape, nucleus, and anterior notch are similar to those of *W. pretiosa*, except that whorls are more convex and shoulder higher. Also, axial ribs disappear at an earlier stage, so the two species are easily distinguished. A Pareora shell in Canterbury Museum is larger (*circa* 70 mm. high), and the ribbing is scarcely developed at all; but, as the single specimen is very imperfect, it is safer classed with *W. cognata* until further material is examined. This specimen was identified by Hutton as *Scaphella attenuata*, and the same specific identification was followed by Suter.

Localities.—Target Gully (type); Pareora.

(C.) PACHYMELON n. subgen.

Shell rather small, thick and heavy, broadly fusiform. Spire short. Nucleus scaphelloid, generally globose. Sculpture of axial ribs tending to become obsolete. Fasciole scarcely marked. Aperture with a shallow anterior sinus. Outer lip convex, thickened and rounded. Columella produced, with 4 or, generally, 5 folds.

Type: *Waihaoia amoriaformis* Marwick.

SYNOPSIS OF SPECIES.

A. Smooth.
- 1. Regularly fusiform, diameter nearly half height .. .. *waitakiensis.*
- 2. Broadly fusiform, diameter much less than half height .. *murdochi.*

B. Ribbed.
- 1. Body tapering regularly to anterior end.
  - (*a.*) Ribbing fine, about 25 per whorl .. .. .. *amoriaformis.*
  - (*b.*) Ribbing coarse, about 15 per whorl, obsolete on body *firma.*
- 2. Body contracted rather quickly below, then straightening out to a rather long beak .. .. *lutea.*

Waihaoia (Pachymelon) waitakiensis n. sp. (Plate 70, fig. 1.)

Shell of moderate size, heavy, fusiform. Spire less than half height of aperture. Spire-whorls only slightly convex; body-whorl rounded, with faint depression on sloping shoulder. Fasciole well marked. Sculpture: first whorls missing, remainder smooth with faint growth-lines. Aperture wide, deeply notched anteriorly. Outer lip convex, ascending, not reflexed. Columella with 4 strong plaits and a fifth very weak posterior one. Inner lip thin.

Holotype in collection of New Zealand Geological Survey, deposited by Dr. P. Marshall.

Height, 70 mm.; diameter, 27 mm.

Locality.—Greensand, left bank Waitaki River, opposite Wharekuri.

The type is somewhat damaged, so that the dimensions given are only approximate. Distinguished from its relative *A. murdochi* by being larger and more slender.

Waihaoia (Pachymelon) murdochi n. sp. (Plate 63, fig. 5.)

Shell of moderate size, solid, fusiform. Spire half height of aperture. Nucleus bulbous scaphelloid, of about 2½ smooth whorls with a large flattened apex. Post-embryonic whorls 4, almost flat on spire, diameter of penultimate one over twice height; body-whorl somewhat inflated, tapering gradually to a broad but not well-marked fasciole. Suture plain. Sculpture: first two whorls have each about 12 weak axial ribs, but these become obsolete and thereafter surface is smooth. Aperture longitudinally hastate, channelled above, deeply and broadly notched below. Outer lip rounded, not reflexed, slightly convex and retreating below, ascending penultimate whorl only slightly. Columella with 6 narrow, well-spaced folds, which decrease in strength from centre anteriorly and posteriorly, top and bottom ones scarcely developed, top one sometimes absent. Inner lip with a light callus anteriorly and posteriorly, not developed in centre.

Holotype in Wanganui Museum.

Height, 51 mm. (estimated); diameter, 24 mm.

Localities.—Awamoa (type); shell-bed, Target Gully, Oamaru.

Waihaoia (Pachymelon) amoriaformis n. sp. (Plate 63, fig. 1.)

Shell of moderate size, solid, fusiform. Spire half height of aperture. Nucleus bulbous scaphelloid, of about 3 smooth whorls, with a large bluntly-pointed apex. Post-embryonic whorls 4, slightly convex on spire; body-whorl inflated, with sloping slightly concave shoulder, below which it is lightly convex and tapering gradually to the inconspicuous fasciole. Suture undulating. Sculpture: 24 to 27 low axial ribs with equal interstices reaching from suture to suture on upper spire-whorls, obsolete on shoulder of penultimate and on whole of body-whorl. Aperture hastate, channelled above, widened below, with a wide shallow anterior notch. Outer lip convex, lightly sinused above, thickened and reflexed, only slightly ascending penultimate whorl. Columella with 6 strong well-separated folds, anterior and posterior ones somewhat lower than others. Inner lip rather thickly calloused.

Holotype in collection of Mr. H. J. Finlay.

Height, 66 mm.; diameter, 30 mm.

Localities.—Shell-bed, Target Gully (type); Mount Harris.

Waihaoia (Pachymelon) firma n. sp. (Plate 70, fig. 2.)

Shell rather small, unequally biconic, solid. Spire conic, about half height of aperture. Nucleus large scaphelloid, of 3 smooth whorls. Post-embryonic whorls 5, with long steep slightly concave shoulder, obtusely angled just above suture; body-whorl contracting regularly to fasciole, which is faintly marked. Sculpture: spire-whorls with about 15 low broadly-rounded axial ribs, very weak on sloping shoulder but slightly nodular just above suture, on penultimate whorl they are also a little stronger immediately below posterior suture, on body-whorl these axials become obsolete and finally disappear. Aperture triangular, channelled above, widely and shallowly notched below. Outer lip damaged in the only specimen, but apparently thick and convex, not ascending. Columella with a thick pad on which are 5 plaits, the anterior one weakest. Inner lip glazed.

Holotype in collection of Mr. H. J. Finlay.

Height, 53 mm.; diameter, 23 mm.

Resembles *A. neglecta*, but distinguished by the straighter outlines, longer shoulder extending almost down to suture, axial ribs more knobbed at the shoulder, fasciole shallow and not separated by a ridge from base.

Waihaoia (Pachymelon) lutea (Watson). (Plate 63, fig. 3.)

1882. *Cymbiola lutea* Watson, *Jour. Linn. Soc.*, vol. 16, p. 33.

1886. *Voluta (Cymbiola) lutea* Watson, *Chall. Rep.*, vol. 15, p. 255, pl. 15, figs. 3 *a*, *b*.

According to the sounding plotted on the Admiralty Chart, this shell was dredged from 275 fathoms about 250 nautical miles west of New Plymouth—not "200 miles west of Cape Farewell," as given by Watson. The original description does not mention the fasciole, and the anterior sinus of the aperture is described as a "broad shallow slightly emarginated minutely-bordered canal." The figures also show that the anterior sinus is quite shallow, and has not formed a prominent fasciole such as is invariably present in *Alcithoe*. Two years ago the writer inadvertently gave the name *Alcithoe lutea* to a new species from the Pliocene of Ngaruroró River. Since the shells appear to be generically distinct, the specific name will have to remain in both cases. This is unfortunate, as it is likely to cause confusion. *W. lutea* has not again been collected either Recent or fossil.

5. SPINOMELON n. gen.

Shell large, somewhat narrowly fusiform. Spire conic, lower than aperture. Body-whorl tapering gradually to well-marked fasciole. Sculpture of axial ribs tending to become obsolete on later whorls but sometimes developing tubercles. Nucleus caricelloid, spike being sharp and strong. Aperture wide, moderately notched below; beak often projecting strongly. Outer lip convex, sometimes slightly reflexed. Columella with 5 or 6 strong plaits.

Type: *Lapparia parki* Suter.

SYNOPSIS OF SPECIES.

A. Axials on spire strong.
  1. Body regularly curved .. .. *enysi.*
  2. Body with a rounded shoulder.
    (*a.*) Shell strong, fasciole well defined, later whorls well ribbed .. *parki.*
    (*b.*) Shell thin, fasciole not defined and with a central fold, later whorls smooth .. .. *benitens.*
  3. Body with a tuberculate shoulder .. .. *speighti.*
B. Axials on spire very fine .. .. *mira.*

Spinomelon enysi n. sp. (Plate 62, fig. 6.)

Shell very large, narrowly fusiform, strong. Spire about half height of aperture. Four whorls remaining on type, slightly convex on spire; body-whorl subcylindrical, slightly convex, contracting gradually to fasciole, which is broad and shallow, the outer side almost horizontal. Sculpture: early spire-whorls with about 15 narrow low ribs with broad interstices, becoming obsolete and leaving penultimate and body-whorls smooth. Aperture high, contracted above to a narrow channel, dilated below with a wide shallow anterior notch. Outer lip convex, expanded, ascending a short distance on penultimate whorl. Columella straight, projecting anteriorly, furnished with 6 well-spaced oblique folds of moderate strength. Inner lip spread as a glaze, sometimes as a fairly thick callus on body-whorl.

Holotype in collection of New Zealand Geological Survey.

Height, 142 mm.; diameter, 50 mm.

Locality.—243, fan-coral bed, Trelissick Basin.

Besides the smooth later whorls, the shallow anterior notch shows that this species is closely related to *S. benitens*, from which it can be distinguished by its size, strength, greater development of ribs, and altogether different shape of body.

Spinomelon benitens (Finlay). (Plate 62, fig. 3.)

1926. *Miomelon benitens* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 250, pl. 55, fig. 6.

Salient features are the smooth polished surface of the later whorls, the thinness of shell-material, shallow anterior notch and projecting columella, and prominent rounded ridge traversing central line of fasciole.

Locality.—Otiake.

Spinomelon parki (Suter). (Plate 62, fig. 8.)

1907. *Lapparia parki* Suter, *Proc. Malac. Soc.*, vol. 7, p. 207, pl. 18, figs. 1, 2 (juv.).

1914. *Lapparia corrugata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 2*, p. 27 (in part).

1917. *Cymbiola (Miomelon) corrugata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 87 (in part).

Shell large, fusiform, strong. Spire half height of aperture. Nucleus of about 2 smooth whorls, with an erect, sharply pointed calcarella. Post-

embryonic whorls about 5½, convex, with a sloping very slightly concave shoulder; body-whorl occupying four-fifths of shell, contracting slowly to large fasciole. Suture undulating. Sculpture: 16 rather low axial ribs with wider interstices, on upper whorls reaching from suture to suture, but on body-whorl not traversing shoulder nor extending far anteriorly; sometimes the ribs die out at an early stage and body-whorl is smooth. Aperture large with subparallel sides, narrowing to a channel above, broadly and moderately notched below. Outer lip convex, reflexed and thickened, scarcely ascending penultimate whorl. Columella with 5 strong well-spaced oblique plaits, anterior and posterior ones rather weaker, also a sixth rudimentary plait posterior to others; inner lip spreading as a thin glaze well over body-whorl.

Height of plesiotype, 116 mm.; diameter, 45 mm.

Localities.—Target Gully; Pareora (type); Mount Harris; Parson's Creek, Oamaru; Callaghan's Hill, Westland.

This handsome shell was wrongly considered by Suter to belong to Hutton's *Voluta corrugata*, which is a short, plump shell with strong ribs extending right across the body-whorl, and which is closely related to *Alcithoe solida* n. sp. The number of folds on the columella of *S. parki* is generally 5 or 6, but sometimes 7; also the stage at which the axial ribs disappear is variable. The only specimens in which ribs persist on the body-whorl are from Mount Harris. The ribbing on the shell from Parson's Creek is but little more developed than that on *S. benitens;* unfortunately the anterior end is broken, so the depth of the apertural notch is not known. *S. enysi* also has ribbing only on the early whorls, but the body-whorl is regularly convex and has not a rounded shoulder-angle.

Spinomelon speighti n. sp. (Plate 64, fig. 7.)

Shell large, broadly fusiform. Spire one-half height of aperture. Whorls 5½, at first convex then bluntly angled below mid-point of whorl; body-whorl with rather broad concave shoulder, below which it is lightly convex and somewhat rapidly contracted but straightening before reaching depressed fasciole. Sculpture: spire-whorls with 11 or 12 strong axial ribs which on later whorls become weaker on sloping shoulder and finally fail to cross it, meanwhile their strength has increased at shoulder angle, and on body-whorl there are 10 strong, laterally extended tubercles. Aperture wide, deeply and widely notched below. Outer lip convex, dilated, reflexed, ascending penultimate whorl. Columella with 5 or 6 well-spaced strong plaits, anterior and posterior weaker than central ones. Inner lip thin, extending out from aperture.

Holotype in Canterbury Museum.

Height, 110 mm.; diameter, 47 mm.

Locality.—Mount Harris, South Canterbury.

None of the specimens seen had the nucleus intact, but the species is undoubtedly closely related to *S. parki.* There is some variation in the strength and number of the tubercles, but they are always fewer and more angled than on *S. parki.* Other points of distinction are a broader body-whorl, more contracted base, and generally more distended aperture.

Spinomelon mira n. sp. (Plate 64, fig. 4.)

Shell large, fusiform. Spire less than one-third height of aperture. Nucleus missing. Post-embryonic whorls 6, the last few rapidly increasing so that slope of spire is slightly concave; first whorls lightly convex, later ones more strongly so, and finally developing a sloping flattened shoulder

without marked angle; body-whorl very long, with slightly concave shoulder and rounded angle, below which contraction is very gradual for a space, then increasing somewhat, finally straightening out again to a long neck which bears a moderately-well-marked convex fasciole, not bounded by ridge. Sculpture: first whorl with about 25 or 30 low axial ribs, on later whorls number increases but ribs become confused with and impossible to separate from irregular crowded growth-ridges; before completion of penultimate whorl indistinct blunt nodules begin to be developed, they increase in strength on body-whorl, where they are axially elongated but do not reach half-way across shoulder nor down body to any distance, their number is about 15, but the last three are obsolete; some of the early whorls have traces of indistinct spirals. Aperture with subparallel sides, contracting rather quickly to a channel above, with wide shallow anterior sinus. Outer lip slightly convex, ascending, thickened not reflexed. Columella long, slightly twisted anteriorly, with 6 folds situated relatively high up, the posterior three on a low pad, the anterior fold very weak, but the strength of others increases posteriorly until fourth, fifth is almost as strong, but sixth or posterior one is weak. Inner lip thin spreading.

Holotype in collection of New Zealand Geological Survey.

Height, 130 mm.; diameter, 46 mm.

Locality.—166, blue clays of eastern slopes of Mount Horrible, Pareora River; Awamoa.

This species is not closely related to any other of those described.

6. METAMELON n. gen.

Shell rather small, broadly fusiform. Spire rather narrow. Body-whorl expanding quickly, contracted again quickly below to a produced neck bearing very prominent fasciole strongly marked off from base. Nucleus caricelloid, spike sharp and high. Sculpture: early species and early whorls of later species practically smooth except for growth-lines, later strong axials appear and in type species a prominent angulation of whorl develops into concave shoulder. Suture impressed. Aperture broad, very deeply notched below. Outer lip sharp, straight. Columella generally with 5 folds.

Type: *Miomelon clifdenensis* Finlay.

SYNOPSIS OF SPECIES.

A. Body-whorl smooth.
  1. Small (under 25 mm.) .. .. *minima.*
  2. Moderate size (40 mm. or over) .. *inermis.*

B. Body-whorl ribbed.
  1. Axials very strong, ending abruptly at shoulder *clifdenensis.*
  2. Axials weak, not defining the shoulder .. *marshalli.*
  3. Axials weak, developing blunt tubercles on shoulder *reverta.*

Metamelon inermis (Finlay). (Plate 69, fig. 14.)

1926. *Miomelon inermis* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 247.

This species is characterized by smooth, convex whorls, contracted base, prominent fasciole, and dilated aperture. The last two whorls of pointed nucleus have weak spiral threads, of which one is stronger than others; these are crossed by very weak axials. Even in neanic stage there are 5 strong spirals on columella.

Localities.—Otiake; Chatton (= *Mitra* n. sp. of Suter, 1921, p. 95), fragment.

Metamelon marshalli n. sp. (Plate 69, fig. 12.)

Shell rather small, broadly fusiform. Spire conic, half height of aperture. Nucleus with high spike. Spire-whorls slightly convex; body-whorl rounded, with short slightly concave sloping shoulder; fasciole prominent, bounded by ridge. Suture impressed, bordered below by a groove on nearing aperture. Sculpture: spire-whorls smooth, with irregular growth-lines; body-whorl with 14 narrow not strong axial ribs with wide interstices, ribs weaken on crossing shoulder and die out on base. Aperture wide, deeply notched below. Outer lip thin, simple, ascending. Columella straight, with 5 rather weak plaits. Inner lip thin.

Holotype in collection of New Zealand Geological Survey, deposited by Dr. P. Marshall.

Height, 56 mm.; diameter, 23 mm.

Locality.—Greensand, left bank Waitaki River, opposite Wharekuri.

Closely related to *M. clifdenensis*, but not quite so extreme—shoulder not so concave, ribs weaker and only present on body, base not so contracted, and suture not so deeply impressed. Some immature specimens in Mr. R. S. Allan's collection have noticeably closer ribbing than the type, and one has a few irregular spiral cords. Also, their suture is appressed, and one has a ridged fasciole. Perhaps more than one species is represented.

Metamelon clifdenensis (Finlay). (Plate 69, fig. 11.)

1926. *Miomelon clifdenensis* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 246, pl. 55, figs. 1–3.

The ontogeny of this shell is peculiar. It commences with a narrow strongly-spiked nucleus of 3 smooth whorls, then comes a cylindrical whorl with almost vertical sides ornamented by fine posteriorly-flexed growth-lines crossed by rather weaker waved spiral lirae. The succeeding whorls are convex, frustoid, and soon develop a slightly concave sloping shoulder. The growth-lines meanwhile have become strong, and about beginning of penultimate whorl they develop into axial ribs. These become very strong on lower half of whorl and form prominent concave shoulder. Anterior notch deep, but fasciole somewhat variable though always well defined. In type it is convex, curving round to anterior point, and separated by narrow chink from inner lip. In paratype columella projects much more anteriorly and fasciole is concave and sunken along outer side, inner side roundly ridged but no chink separates inner lip.

Locality.—Clifden (bands 6A, 6B).

Metamelon reverta (Finlay). (Plate 69, fig. 15.)

1926. *Miomelon reverta* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 247.

This is an offshoot from the *S. inermis* type of shell, less specialized than *S. clifdenensis*, the ribbing and angulation of body-whorl being much restrained. The marked outward curve of anterior end of columella shown by type is probably not a constant character. In a younger topotype columella is almost straight; similarly, the curvature of this part in *S. clifdenensis* is variable.

Localities.—Target Gully (type); 175, Ardgowan shell-bed; Mount Harris.

The last two specimens lack the body-whorl, and so resemble *M. inermis*; there is thus some doubt about their identification.

Metamelon minima n. sp. (Plate 69, fig. 10.)

Shell small, fusiform. Spire conic, over two-thirds height of aperture. Nucleus scaphelloid, of 2 smooth whorls. Post-embryonic whorls 4½, convex on spire with flattened shoulder; body-whorl regularly convex, slightly compressed below suture, contracted fairly quickly and constricted before joining well-marked fasciole. Surface almost smooth, with numerous growth-lines which on spire are grouped into weak irregular axial ribs. Aperture moderate, deeply notched below. Outer lip thin, simple, scarcely ascending. Columella with 4 spaced folds; inner lip spreading well out.

Holotype in collection of Mr. H. J. Finlay.

Height, 24 mm.; diameter, 9 mm.

Localities.—Otiake (type); All Day Bay; Mount Harris (R. S. Allan collection).

The generic position is uncertain, because the nucleus has not the prominent spike possessed by all other members of *Metamelon.* The fasciole and constricted body-whorl, however, suggest this position. If correct, though persisting in the Mount Harris beds, *M. minima* is a primitive type representing the kind of shell from which *M. inermis* sprung.

7. ALCITHOE H. and A. Adams, 1858.

Type: *Buccinum arabicum* Martyn.

SYNOPSIS OF SPECIES.

1. *Large shells, generally over 70 mm. in height.*

A. Spire less than two-thirds apertural height.
- (1.) Body tubercles strong.
  - (*a.*) Body tapering regularly.
    - Four folds.
      - Body-shoulder steep .. .. .. *hurupiensis.*
      - Body-shoulder not steep .. .. .. *familiaris.*
    - Five folds.
      - Columella padded .. .. .. *compressa.*
      - Folds not very oblique .. .. .. *armigera.*
      - Shoulder appressed .. .. .. *robusta.*
      - Shoulder abutting .. .. .. *jaculoides.*
  - (*b.*) Body slightly inflated, contracted below.
    - Angle about middle of spire-whorls .. .. *arabica.*
    - Angle low down, near suture.
      - Nodules very long, sharp on spire .. .. *arabicula.*
      - Spire almost smooth, very strong, sharp, tubercles on body .. .. .. *transformis.*
      - Shell very large, body expanding suddenly .. *oliveri.*
      - Moderate size, nodules blunt, inner lip with raised edge .. .. *depressa.*
- (2.) Body tubercles weak or absent.
  - (*a.*) Diameter one-third height of shell, tubercles weak .. *acuta.*
  - (*b.*) Diameter over one-third height of shell.
    - Body cylindrical, inner lip thin .. .. *cylindrica.*
    - Body inflated, base gradually contracting, inner lip with raised edge, tubercles often absent .. *swainsoni.*
    - Body inflated, base quickly contracting, inner lip thin, no tubercles .. .. *larochei.*
- (3.) Axially ribbed.
  - (*a.*) Whorls angled .. .. *haweraensis.*
  - (*b.*) Whorls rounded, irregular spirals on early whorls .. *residua.*

B. Spire two-thirds height of aperture.
(1.) Axial ribs scarcely tuberculate .. .. .. *whakinoensis.*
(2.) Well-developed tubercles.
(*a.*) Strong axials.
Sharp tubercles .. .. *turrita.*
Blunt tubercles .. .. *sequax.*
(*b.*) Weak axials.
Columella padded, 6 folds .. .. .. *wekaensis.*
Columella straight, 5 folds; inner lip thick, raised *detrita.*
Columella straight, 4 folds; inner lip thin, not raised .. .. *lutea.*
(3.) Whorls smooth .. .. *nukumaruensis.*

2. *Small shells, generally under 70 mm.*

A. Diameter one-third height or less.
Tapering body with ribs .. .. *mackayi.*
Cylindrical, smooth body.. .. .. *hedleyi.*
B. Diameter more than one-third, less than one-half height of shell.
(1.) Four folds.
(*a.*) Spire nearly as high as aperture.
Body strongly ribbed .. .. .. *gatesi.*
Body smooth .. .. *exigua.*
Body knobbed .. .. *finlayi.*
(*b.*) Spire much lower than aperture.
Spire conic.
Body inflated, lip dilated .. .. .. *irregularis.*
Body not inflated, lip not dilated .. .. *scopi.*
(*c.*) Spire turreted.
Axial ribs on body .. .. *subgracilis.*
Body smooth or tubercled .. .. .. *gracilis.*
(2.) Five folds.
Columella straight.
Lip reflexed .. .. *reflexa.*
Lip not reflexed .. .. *lepida.*
Columella padded .. .. *neglecta.*
C. Diameter one-half height of shell.
Body with axial ribs.
Thirteen ribs, spire conic .. .. *solida.*
Seventeen ribs, spire turreted .. .. *brevis.*
Body tuberculate.
Four folds .. .. *dilatata.*
Five folds .. .. *parva.*

Alcithoe turrita (Suter). (Plate 66, fig. 8.)

1917. *Fulgoraria (Alcithoe) arabica* var. *turrita* Suter, *N.Z. Geol. Surv. Pal. Bull.* 5, p. 39, pl. 5, fig. 4.
1920. *Fulguraria (Alcithoe) turrita* Suter, Marsh. & Murd., *Trans. N.Z. Inst.*, vol. 52, p. 132.

Axial ribs on spire narrow but strong, and tubercles on body-whorl much compressed. Columella bent sharply to rear below, ending in sloping knife-like edge about ¼ in. long.

Other than the type, no example of this species has been seen; but there is a related species from Mount Brown, and another from Nukumaru.

Locality.—Blue Cliffs, South Canterbury.

Alcithoe wekaensis n. sp. (Plate 68, fig. 4.)

Shell large, fusiform, strong. Spire turreted, slightly less than two-thirds height of aperture. Nucleus scaphelloid, of about 2½ smooth whorls. Post-embryonic whorls 5, obtusely angled about the middle and with a

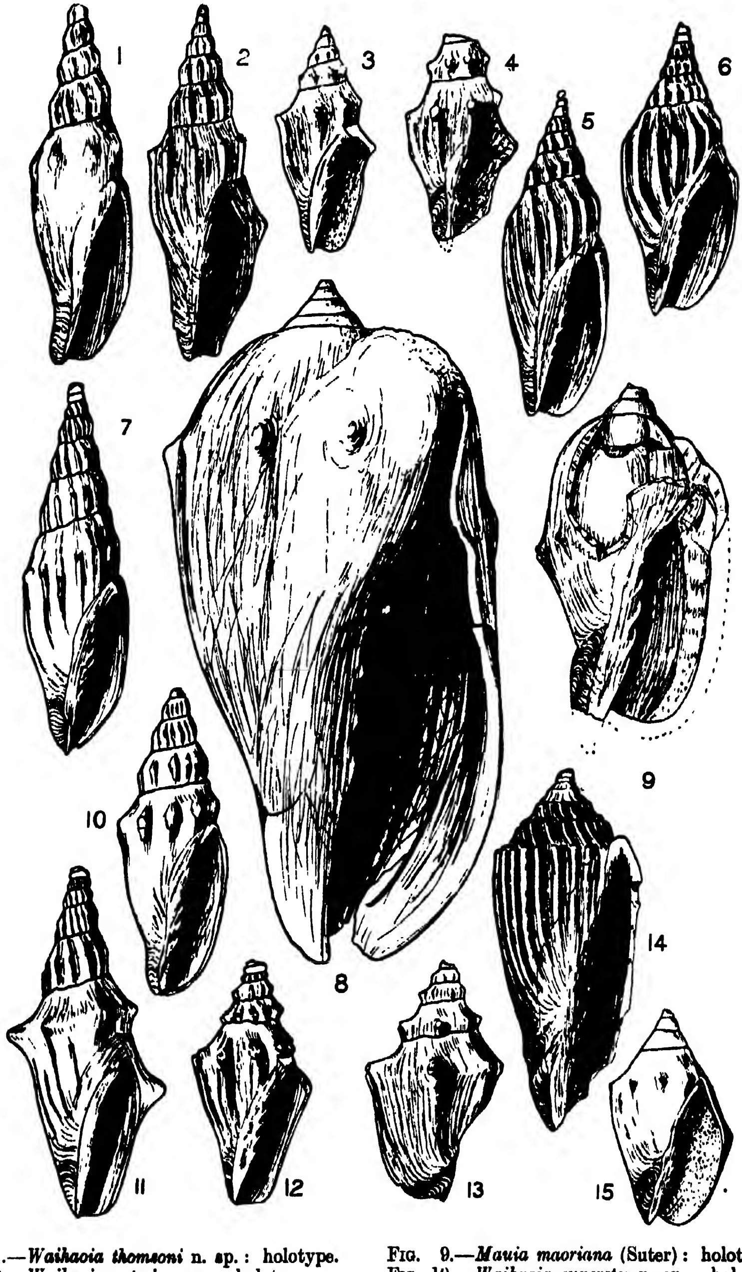

Fig. 1.—*Waihaoia thomsoni* n. sp.: holotype.
Fig. 2.—*Waihaoia suteri* n. sp.: holotype.
Fig. 3.—*Waihaoia confusa* n. sp.: holotype.
Fig. 4.—*Mauia angusta* (Suter): lectotype.
Fig. 5.—*Waihaoia allani* n. sp.: holotype.
Fig. 6.—*Waihaoia regularis* (Finlay): holotype.
Fig. 7.—*Waihaoia bathgatei* (Finlay): holotype.
Fig. 8.—*Mauia huttoni* (Suter): holotype.
Fig. 9.—*Mauia maoriana* (Suter): holotype.
Fig. 10.—*Waihaoia superstes* n. sp.: holotype.
Fig. 11.—*Waihaoia phymatias* (Finlay): holotype.
Fig. 12.—*Waihaoia dyscrita* (Finlay): holotype.
Fig. 13.—*Mauia angusta* (Suter): plesiotype.
Fig. 14.—*Mauia insignis* n. sp.: holotype.
Fig. 15.—*Mauia biconica* (Suter): holotype.

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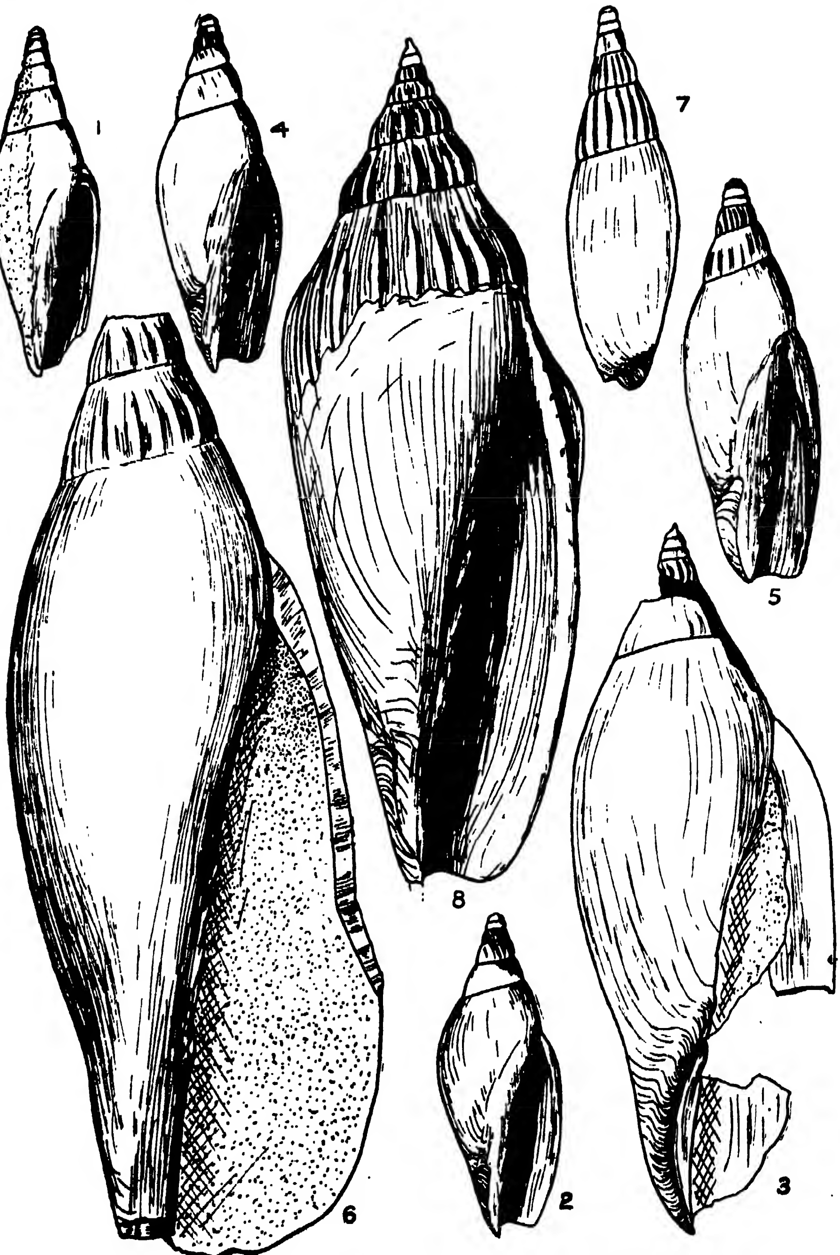

Fig. 1.—*Waihaoia (Teremelon) elegantissima* (Suter): holotype.
Fig. 2.—*Waihaoia (Teremelon) tumidior* (Finlay): holotype.
Fig. 3.—*Spinomelon benitens* (Finlay): holotype.
Fig. 4.—*Waihaoia (Teremelon) awamoaensis* n. sp.: holotype.
Fig. 5.—*Waihaoia (Teremelon) cognata* (Finlay): holotype.
Fig. 6.—*Spinomelon enysi* n. sp.: holotype.
Fig. 7.—*Waihaoia (Teremelon) pretiosa* (Finlay): holotype.
Fig. 8.—*Spinomelon parki* (Suter): Mount Harris.

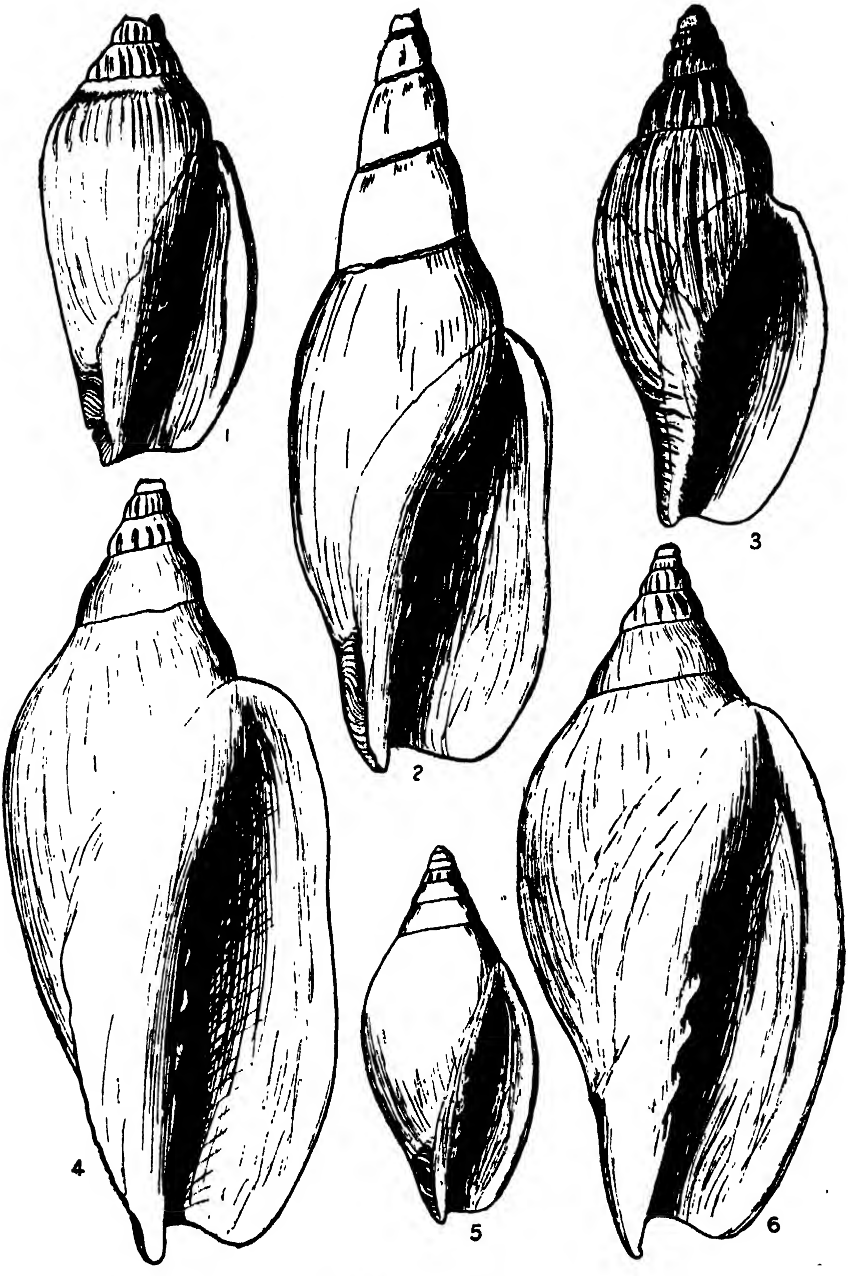

FIG. 1.—*Waihaoia (Pachymelon) amoriaformis* n. sp.: holotype.
FIG. 2.—*Alcithoe nukumaruensis* (Marsh. & Murd.): holotype.
FIG. 3.—*Waihaoia (Pachymelon) lutea* (Watson): after Watson.
FIG. 4.—*Alcithoe swainsoni* n. sp.: Recent, Paekakariki.
FIG. 5.—*Waihaoia (Pachymelon) murdochi* n. sp.: holotype.
FIG. 6.—*Alcithoe larochei* n. sp.: holotype.

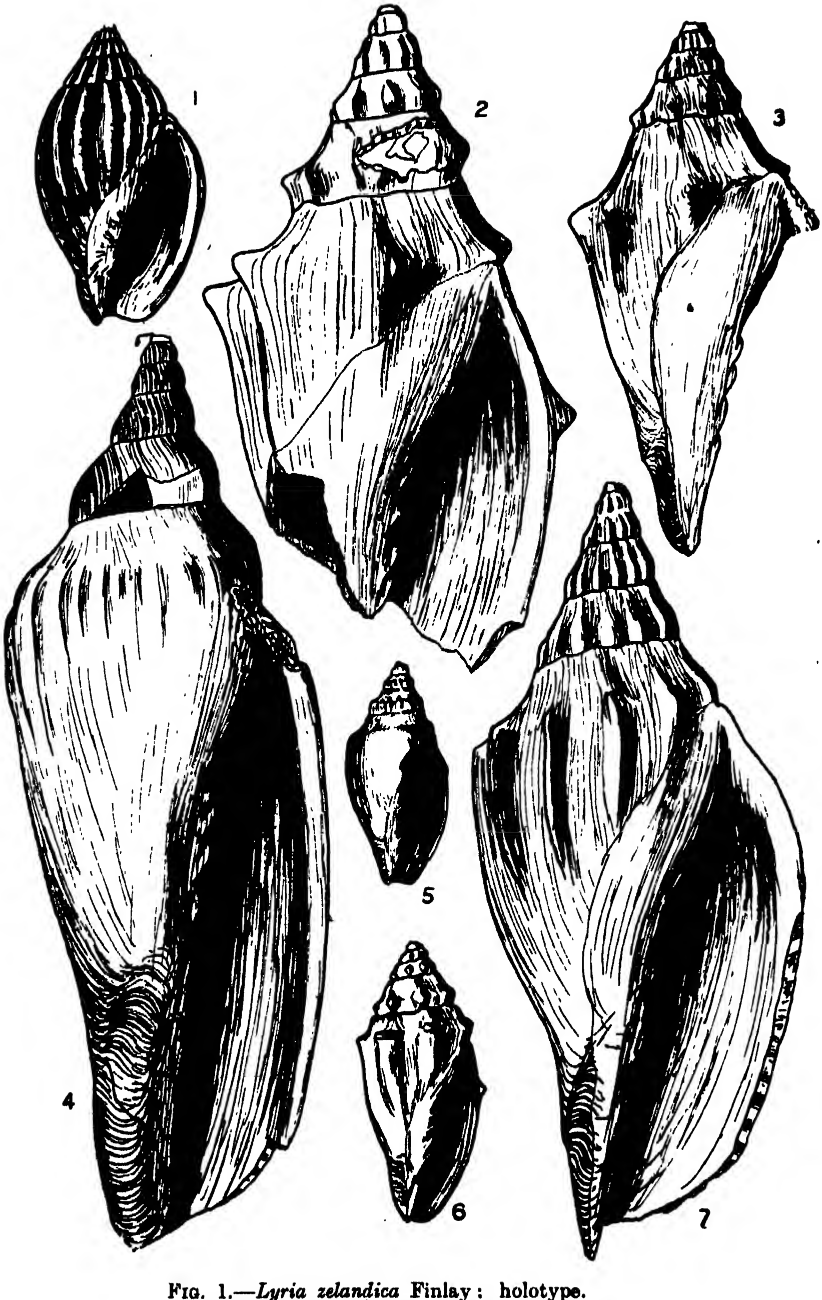

Fig. 1.—*Lyria zelandica* Finlay: holotype.
Fig. 2.—*Alcithoe familiaris* n. sp.: holotype.
Fig. 3.—*Alcithoe hurupiensis* n. sp.: syntype.
Fig. 4.—*Spinomelon mira* n. sp.: holotype.
Fig. 5.—*Waihaoia scitula* n. sp.: holotype.
Fig. 6.—*Waihaoia aculeata* (Hutton): holotype, × 2.
Fig. 7.—*Spinomelon speighti* n. sp.: holotype.

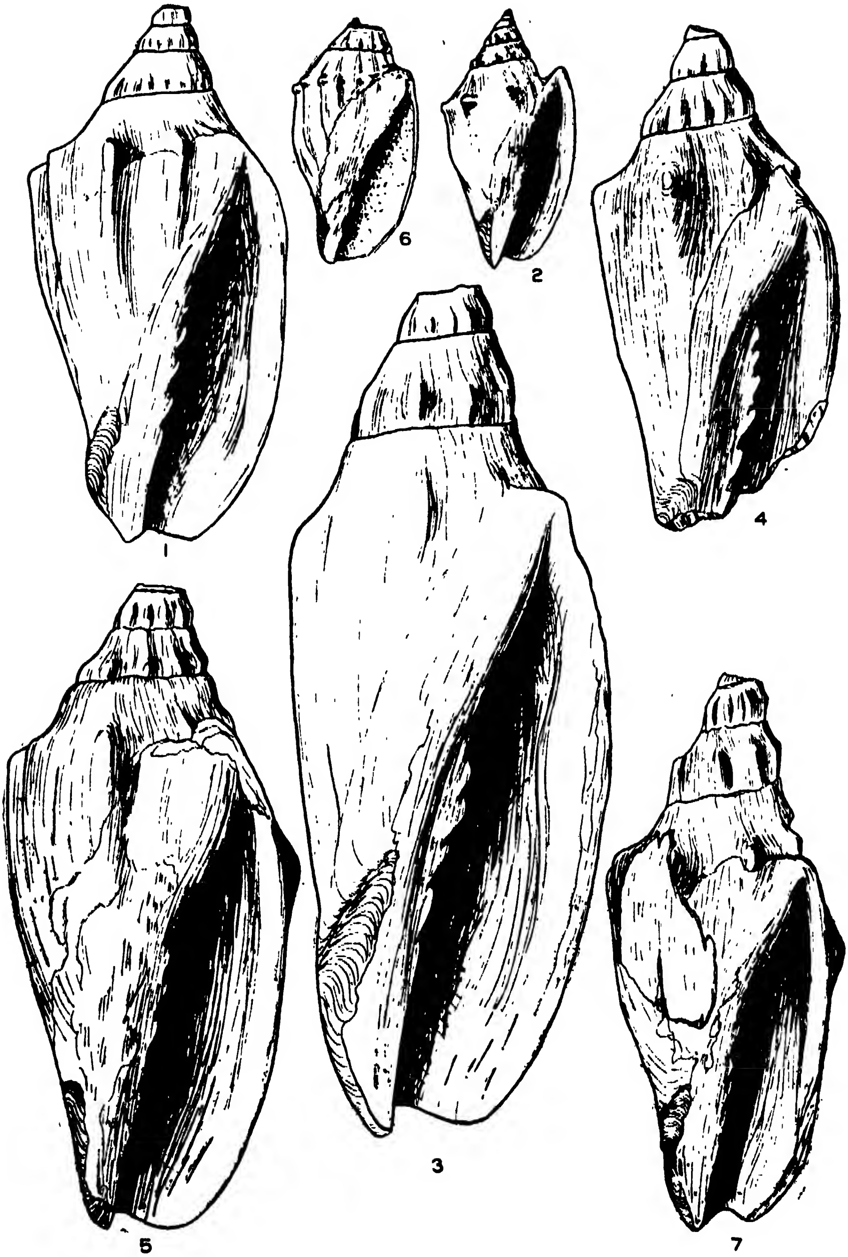

FIG. 1.—*Alcithoe armigera* n. sp. : holotype.
FIG. 2.—*Alcithoe dilatata* n. sp. : holotype.
FIG. 3.—*Alcithoe cylindrica* n. sp. : holotype.
FIG. 4.—*Alcithoe compressa* n. sp. : holotype.
FIG. 5.—*Alcithoe robusta* n. sp. : holotype.
FIG. 6.—*Alcithoe parva* n. sp. : holotype.
FIG. 7.—*Alcithoe sequax* n. sp. : holotype.

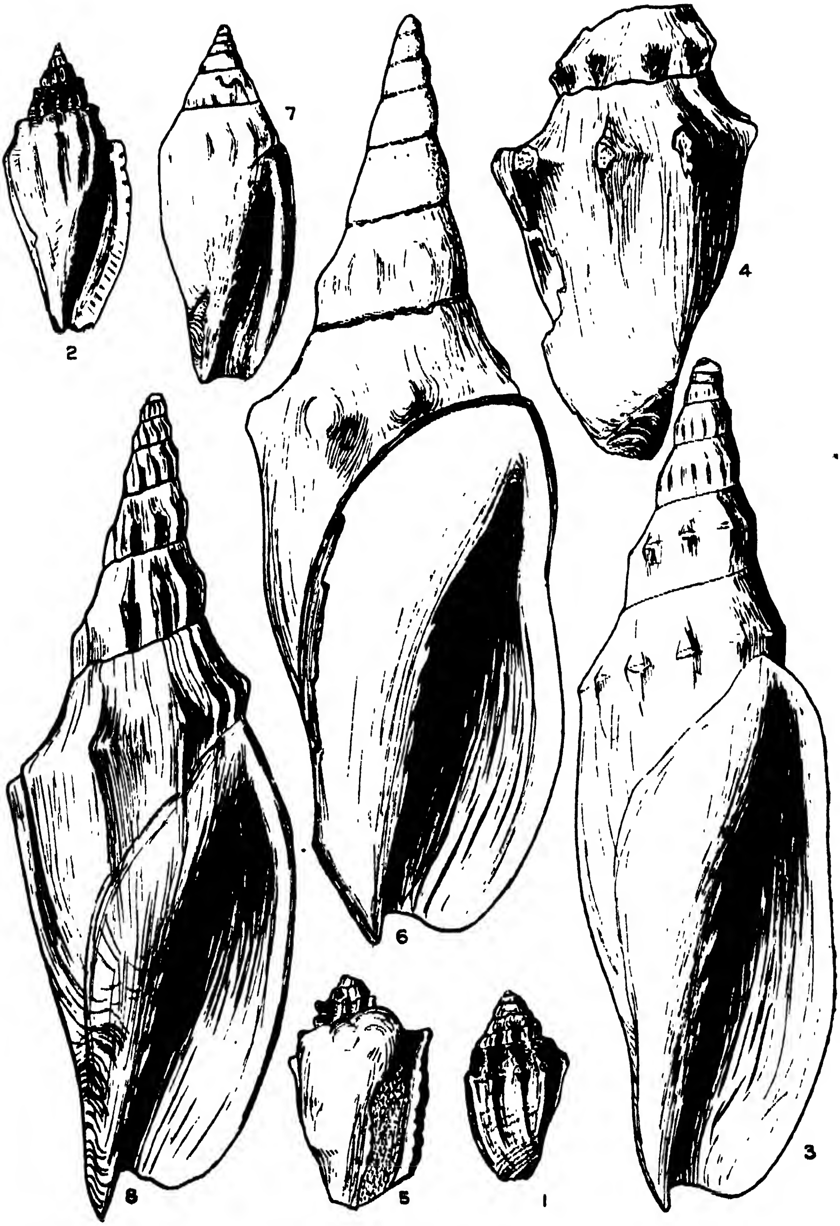

FIG. 1.—*Notoplejona lata* n. sp. : holotype.
FIG. 2.—*Notoplejona necopinata* (Suter) : Waihao Downs.
FIG. 3.—*Alcithoe acuta* n. sp. : holotype.
FIG. 4.—*Alcithoe arabicula* n. sp. : holotype.
FIG. 5.—*Notoplejona necopinata* (Suter) : Kakahu.
FIG. 6.—*Alcithoe detrita* n. sp. : holotype.
FIG. 7.—*Alcithoe neglecta* n. sp. : holotype.
FIG. 8.—*Alcithoe turrita* (Suter) : holotype.

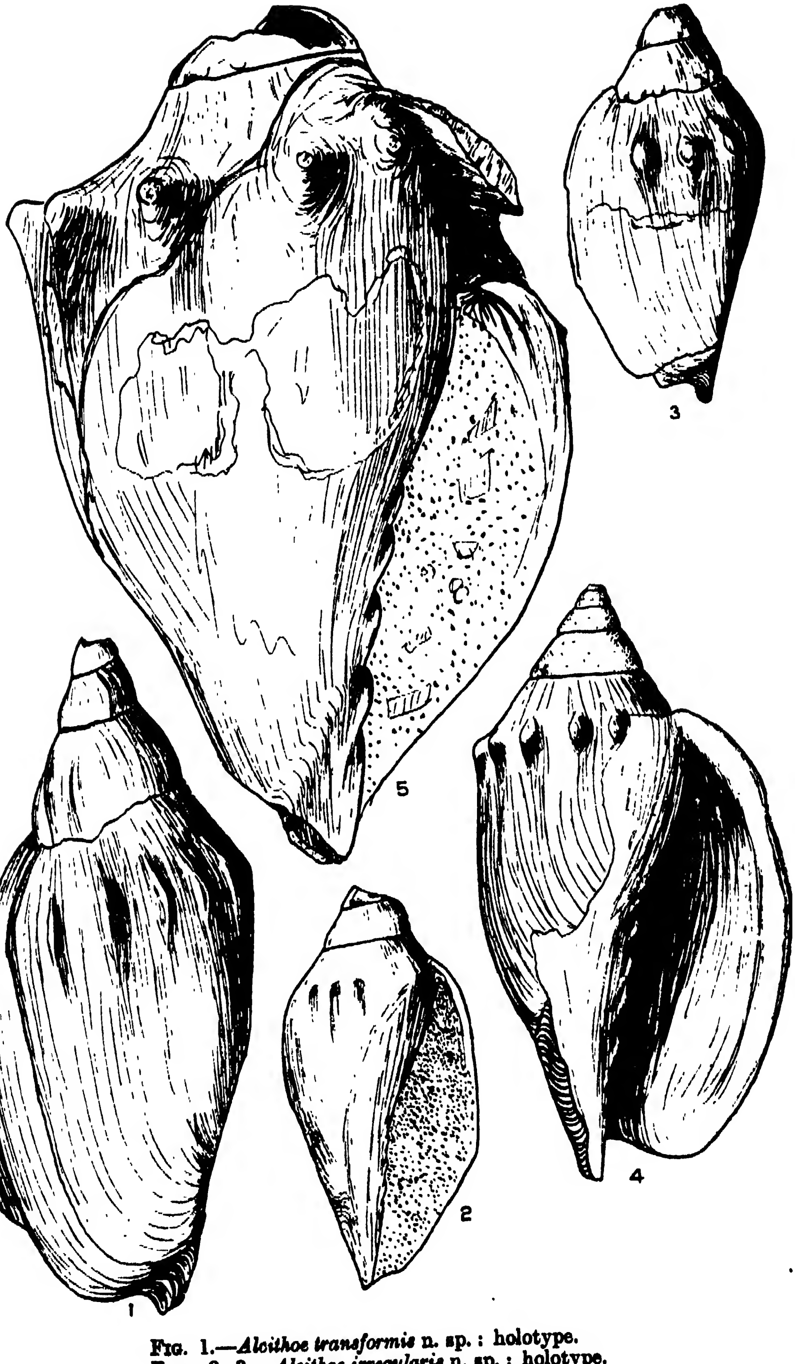

Fig. 1.—*Alcithoe transformis* n. sp.: holotype.
Figs. 2, 3.—*Alcithoe irregularis* n. sp.: holotype.
Fig. 4.—*Alcithoe depressa* (Suter): holotype.
Fig. 5.—*Alcithoe oliveri* n. sp.: holotype.

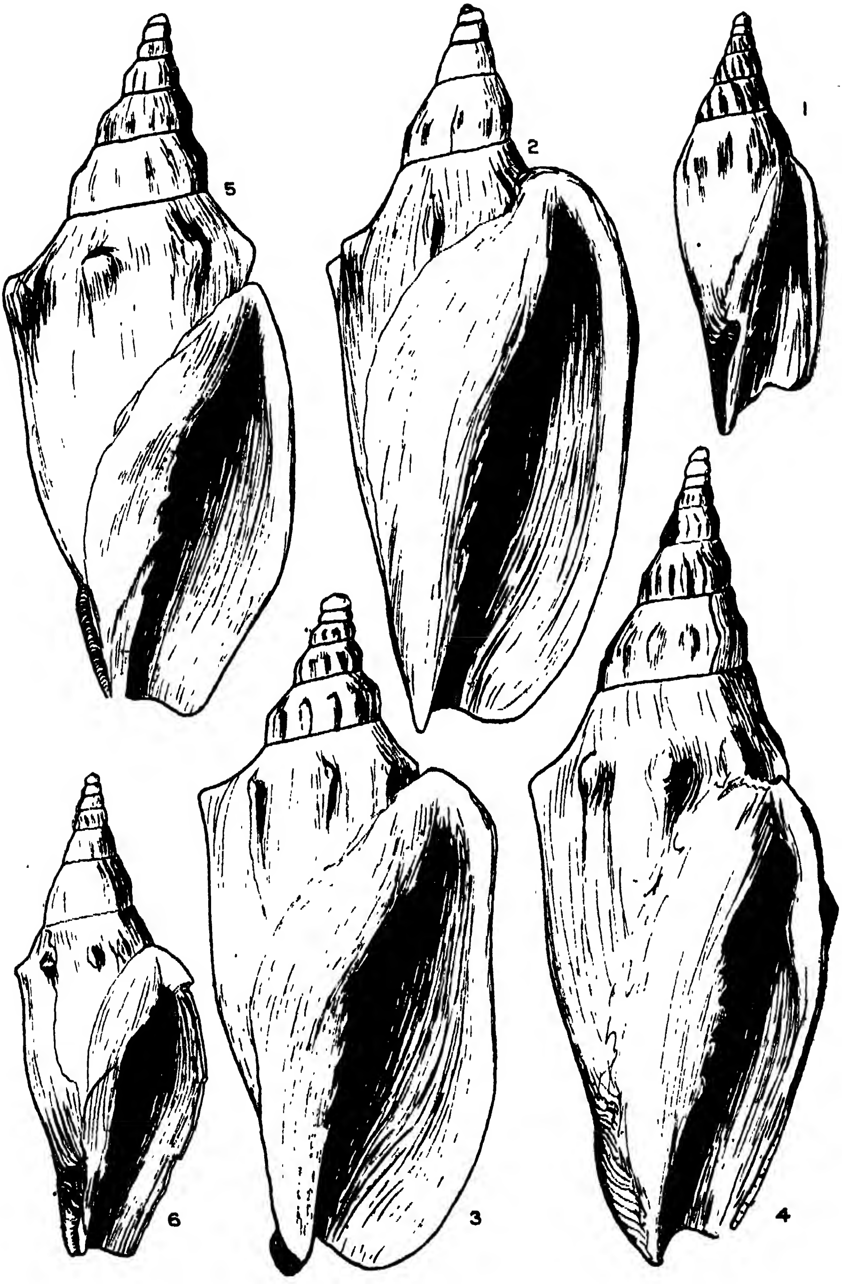

Fig. 1.—*Alcithoe lepida* n. sp.: holotype.
Fig. 2.—*Alcithoe jaculoides* Powell: paratype.
Fig. 3.—*Alcithoe arabica* (Martyn): Tauranga, Recent.
Fig. 4.—*Alcithoe wekaensis* n. sp.: holotype.
Fig. 5.—*Alcithoe lutea* Marwick: holotype.
Fig. 6.—*Alcithoe reflexa* n. sp.: holotype.

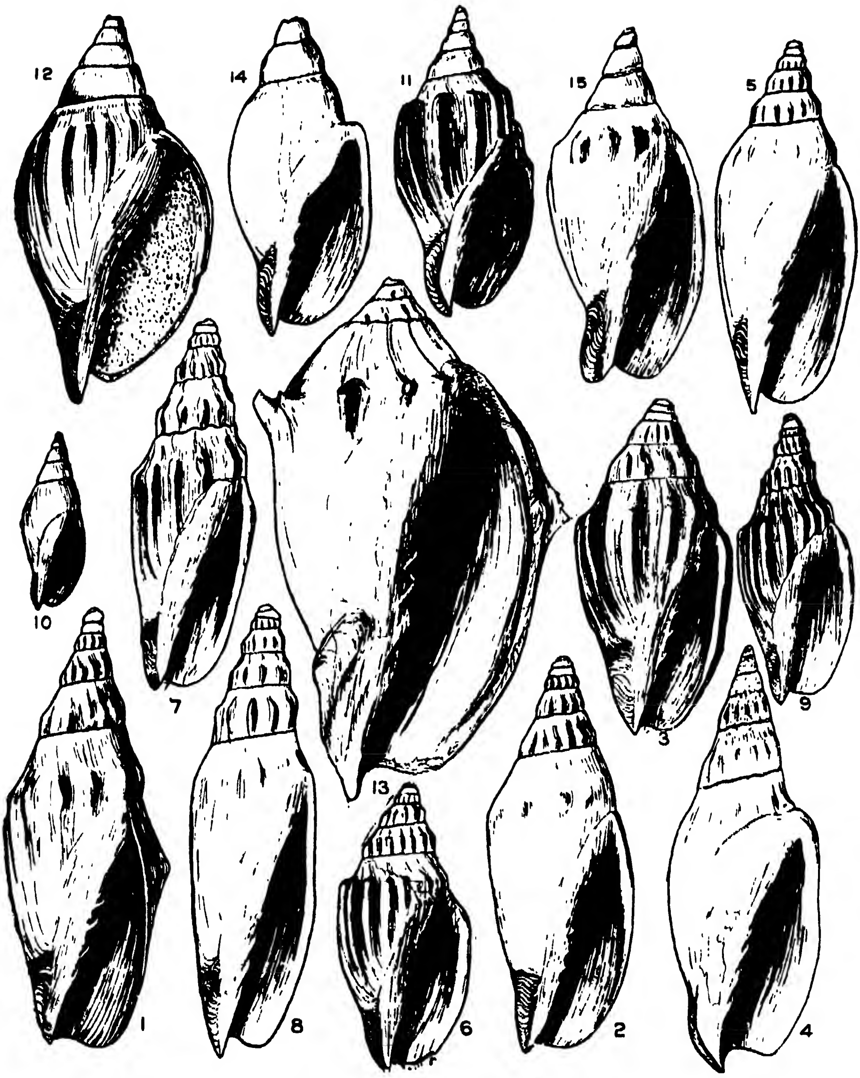

FIG. 1.—*Alcithoe finlayi* n. sp. : holotype.
FIG. 2.—*Alcithoe scopi* n. sp. : holotype.
FIG. 3.—*Alcithoe solida* n. sp. : holotype.
FIG. 4.—*Alcithoe exigua* n. sp. : holotype.
FIG. 5.—*Alcithoe gracilis* (Swainson) : Castlecliff.
FIG. 6.—*Alcithoe brevis* n. sp. : holotype.
FIG. 7.—*Alcithoe mackayi* n. sp. : holotype.
FIG. 8.—*Alcithoe hedleyi* (Murdoch and Suter) : holotype.
FIG. 9.—*Alcithoe subgracilis* n. sp. : holotype.
FIG. 10.—*Metamelon minima* n. sp. : holotype.
FIG. 11.—*Metamelon clifdenensis* (Finlay) : holotype.
FIG. 12.—*Metamelon marshalli* n. sp. : holotype.
FIG. 13.—*Mauia curvispina* n. sp. : holotype.
FIG. 14.—*Metamelon inermis* (Finlay) : holotype.
FIG. 15.—*Metamelon reverta* (Finlay) : holotype.

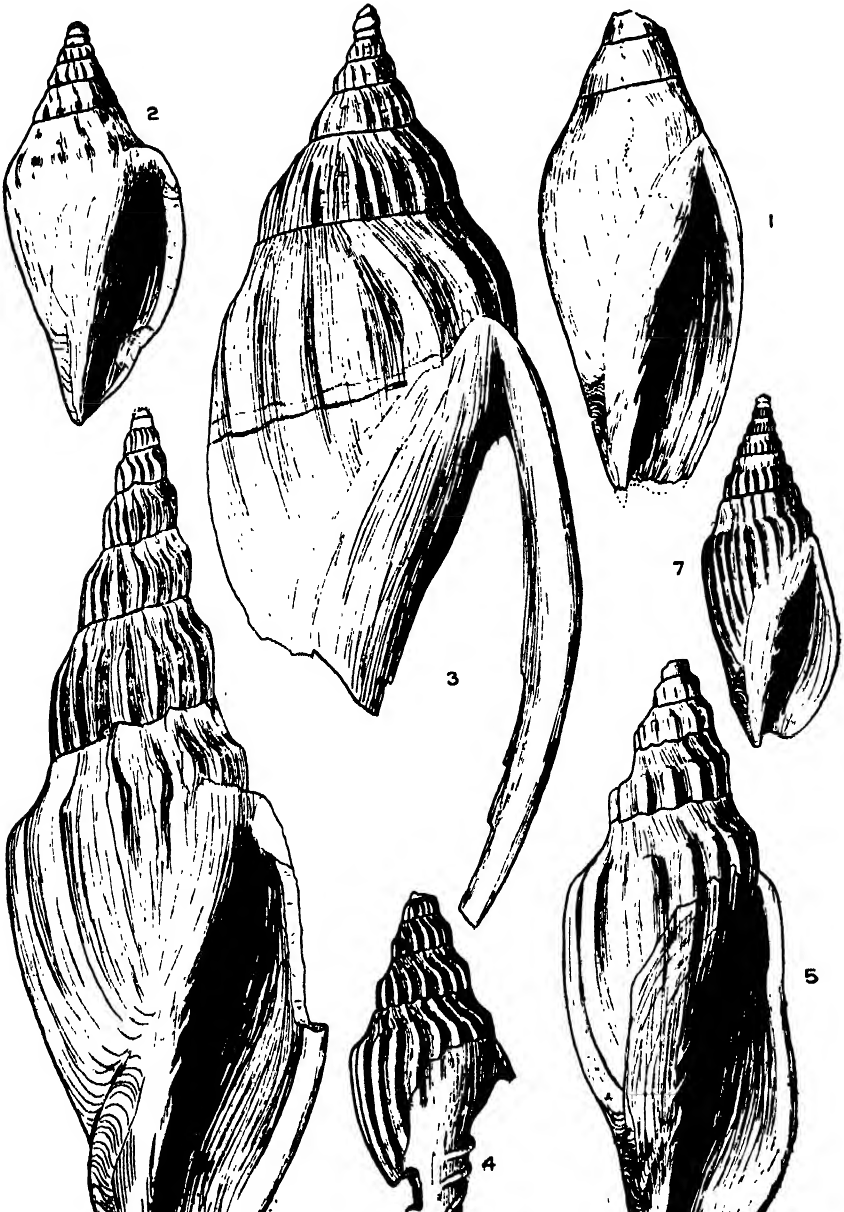

Fig. 1.—*Waihaoia (Pachymelon) waitakiensis* n. sp. : holotype.
Fig. 2.—*Waihaoia (Pachymelon) firma* n. sp. : holotype.
Fig. 3.—*Alcithoe residua* (Finlay) : holotype.
Fig. 4.—*Waihaoia rugosa* n. sp. : holotype.
Fig. 5.—*Alcithoe haweraensis* n. sp. : holotype.
Fig. 6.—*Alcithoe whakinoensis* n. sp. : holotype.
Fig. 7.—*Alcithoe gatesi* new name : holotype.

very steep shoulder; body-whorl slightly convex below shoulder, contracting gradually to large rounded fasciole which is turned strongly inwards and backwards. Sculpture: spire-whorls with about 14 rather weak axial ribs which scarcely reach sutures and are raised into blunt angle about middle of whorl, penultimate whorl with 10 and body-whorl with 8 large strong tubercles which do not extend far axially. Aperture high, triangular, deeply and broadly notched below, channelled above. Outer lip slightly distended, reflexed and thickened, especially at a point slightly lower than central line of tubercles, ascending somewhat on penultimate whorl. Columella swollen in region of folds, which are 6 in number, anterior one weak; columella bent rather strongly backwards and ends in sharp convex edge. Inner lip spreading as thick glaze for some distance from aperture.

Holotype in collection of Mr. H. J. Finlay.

Height, 110 mm.; diameter, 42·5 mm.

Locality.—Lower shell-bed in uppermost Mount Brown beds.

Distinguished from *A. turrita* by its stronger build, lower spire, weaker axials, blunter tubercles, and different disposition of anterior part of columella and fasciole; also, columellar folds are more numerous and placed on prominent convexity.

Alcithoe detrita n. sp. (Plate 66, fig. 6.)

Shell large, fusiform. Spire narrow, nearly as high as aperture. Spire-whorls at first slightly convex, then bluntly angled about middle; body-whorl with prominent shoulder, below which it is straightened, then contracted fairly quickly to prominent fasciole, which is convex and curves inwards. Sculpture: surface is generally eroded, but a fine specimen in Mr. Allan's collection shows 11–12 obsolete nodules on shoulder of spire-whorls, body-whorl with 5–8 strong rounded knobs on shoulder-angle. Aperture wide, contracted to channel above, deeply notched below. Outer lip thickened, slightly reflexed, ascending to angle; most specimens show a marked contraction in posterior extension of aperture during thickening of outer lip. Columella straight, with 5 strong folds, posterior often weak. Inner lip thickly calloused, sometimes with raised edge in fasciolar region.

Holotype in collection of New Zealand Geological Survey.

Height, 185 mm.; diameter, 47 mm.

Localities.—Brown sands at boat-landing, Nukumaru; 1105, arenaceous mudstone, Mangatahi Stream, Ngaruroro River.

This is the knobbed shell identified as *Alcithoe turrita* by Marshall and Murdoch (1920, p. 132). *A. turrita* has a narrower and more regularly tapering body-whorl; its tubercles are more numerous, sharper, and elongated into axial ribs on spire and body; and the inner lip is not raised into a calloused pad. *A. wekaensis* is more closely related, but can be distinguished by wider spire-angle, pad on columella, which bears 6 folds, decreasing in strength from centre, also by thinner lip and more numerous and longer axials on spire-whorls.

A. nukumaruensis differs only in the absence of tubercles, and narrower body-whorl.

Alcithoe nukumaruensis (Marshall and Murdoch). (Plate 63, fig. 2.)

Fulguraria (Alcithoe) turrita nukumaruensis Marsh. & Murd., *Trans. N.Z. Inst.*, vol. 52, p. 133, pl. 9, figs. 18, 19.

Locality.—Nukumaru, brown sands at boat-landing.

Alcithoe cylindrica n. sp. (Plate 65, fig. 3.)

Shell large, subcylindrical, strong. Spire turreted, under half height of aperture. Whorls 4 remaining, bluntly angled about the middle, with a very steep slightly concave shoulder; body-whorl contracting very little to large curved slightly convex fasciole, from which it is separated by broad low ridge. Sculpture: spire-whorls with about 12 low axially elongated tubercles, 8 on penultimate and 6 obsolete ones on body-whorl. Aperture high, triangular, channelled above, deeply and broadly notched below. Outer lip thickened and reflexed, ascending to angle of penultimate whorl. Columella thickly padded in region of folds, which are 6 in number, the anterior and posterior being weakest. Inner lip extending some distance from aperture, and sometimes thickly coated.

Holotype in collection of Mr. H. J. Finlay.

Height, 125 mm.; diameter, 46 mm.

Locality.—Shell-bed, Target Gully, Oamaru.

Alcithoe compressa n. sp. (Plate 65, fig. 4.)

Shell fairly large, heavy. Spire about one-half height of aperture. Spire-whorls with diameter twice height, bluntly angled below middle and with a long sloping shoulder; body-whorl with high concave shoulder, below which it is slightly convex and gradually contracted to fasciole. Suture undulating. Sculpture: spire-whorls at first with about 12 broad weak axial ribs, penultimate whorl with 11, last 4 raised into strong blunt tubercles extending axially to suture below but not over shoulder; body-whorl with 6 strong sharp laterally-compressed tubercles which extend a short distance anteriorly, between them whorl is deeply concave and flattened. Aperture long and narrow, channelled above, deeply notched below. Outer lip thickened, a little reflexed, and ascending with a shallow sinus to line of shoulder. Columella padded, with 6 oblique plaits, anterior and posterior weak, others very strong, interspaces equal to folds. Parietal wall with thick pad of callus.

Holotype in the collection of Mr. H. J. Finlay.

Height, 85 mm. (estimated); diameter, 35 mm.

Locality.—Shell-bed, Target Gully.

Alcithoe armigera n. sp. (Plate 65, fig. 1.)

Shell of moderate size, heavy. Spire conic, under half height of aperture. Nucleus missing. Post-embryonic whorls 4½, early ones convex, later ones with a flattened shoulder, angle blunt and only slightly above suture; body-whorl with broad concave shoulder, below which it contracts somewhat quickly, then straightens out for short distance before reaching prominent fasciole, which is bounded above by ridge and curves inward. Sculpture: early whorls with large number of weak axials, probably about 30 per whorl, these increase rapidly in strength; on penultimate whorl about 16 blunt knobs extending to anterior suture but not above shoulder-angle; on body-whorl are 7 strong sharp tubercles with steeper anterior than posterior slope, and elongated anteriorly but not advancing far on shoulder. Aperture wide, angled above, deeply notched below; outer lip convex, ascending, thickened and reflexed. Columella with 5 strong plaits, strongest in middle. Inner lip spread out well over body, edge not defined.

Holotype in collection of Mr. H. J. Finlay.

Height, 75 mm.; diameter, 35 mm.

Locality.—Shell-bed, Ardgowan.

Alcithoe robusta n. sp. (Plate 65, fig. 5.)

Shell large and heavy. Spire conic, about one-third the height of aperture. Spire-whorls with height from half to two-fifths of diameter, bluntly angled below middle, shoulder long, sloping and concave; body-whorl contracting slowly below shoulder to fasciole, which is not prominently raised. Suture undulating. Sculpture: body-whorl with 8 strong blunt nodules, which are extended somewhat anteriorly to form low axials; penultimate whorls with 10 and previous one with 12 broad low axial ribs forming blunt tubercles on shoulder-angle but weakening quickly posteriorly. Aperture long and narrow, deeply notched below, outer lip slightly convex, thickened and reflexed, ascending to shoulder-angle. Columella with 5 strong oblique plaits, the second and third from below slightly thicker than others. Parietal wall with pad of callus. Inner lip forming a thin glaze extending well out across shell.

Holotype in collection of Mr. H. J. Finlay.

Height, 94 mm; diameter, 40 mm.

Localities.—Mount Harris; 559, Black-birch Creek, Blairich (smaller than Mount Harris specimen).

Alcithoe sequax n. sp. (Plate 65, fig. 7.)

Shell of moderate size. Spire turreted, over half height of aperture. Only 3½ whorls remaining, top one obtusely angled slightly above mid-point, penultimate with concave shoulder and prominent angle well above mid-point, body-whorl also with strong concave shoulder below which it contracts fairly quickly to beak; fasciole well marked, somewhat flattened along outer part. Sculpture: spire-whorl with 11 rounded axial ribs which die away on shoulder; on penultimate whorl 9 strong axials with wide interspaces, forming blunt knobs on shoulder-angle but weakening rapidly above and below; body-whorl with 7 strong tubercles increasing in size until sixth, which is very large, last one quite small. Aperture rather wide, deeply notched anteriorly. Outer lip convex, ascending, thickened and reflexed. Columella with 5 low broad plaits, middle one strongest. Inner lip thick, widespread.

Holotype in collection of Mr. H. J. Finlay.

Height, 78 mm.; diameter, 32 mm.

Locality.—Mount Harris.

Easily distinguished from *A. robusta* and *A. armigera* by the high shoulder of the spire-whorls, also by the fewer axials.

Alcithoe familiaris n. sp. (Plate 64, fig. 2.)

Shell large. Spire turreted, about three-fifths height of aperture. Spire-whorls at first lightly convex but soon becoming obtusely angled about middle, later the angulation becomes sharper and shifts lower down on whorl, forming a sloping shoulder, at first slightly, later decidedly convex; body-whorl contracting below shoulder rather quickly. Sculpture at first of about 11 rounded axial ribs extending from anterior suture up to angle but very weak across shoulder; later the axials decrease to 10, then 9, they become broad and low and bluntly knobbed at angle; penultimate whorl with 7 sharp strong tubercles with wide interspaces, axially extended below suture; body-whorl with 6 very strong high sharp tubercles, front face steeper than back, extending axially for short distance down shell. Aperture wide. Outer lip convex, ascending, thickened, reflexed.

Columella with 4 strong folds, the central ones stronger. Inner lip thin, wide-spreading.

Holotype in collection of Mr. H. J. Finlay.

Height (estimated), 120 mm.; diameter, 54 mm.

Locality.—Mount Harris.

Not unlike *A. arabica*, but with fewer axials, although a wider shell. Further, there are only 4 folds on the columella, and the ribs develop into spines at an earlier stage.

Alcithoe irregularis n. sp. (Plate 67, figs. 2, 3.)

Shell rather small. Spire conic, between one-half and one-third height of aperture. Nucleus and early conch-whorls missing; later spire-whorls obscurely angled low down near suture, and with a long sloping shoulder; body-whorl inflated, with concave shoulder, below which it is convex and does not contract for some distance, then it slopes regularly to the anterior end; fasciole, flattened, not conspicuous. Sculpture: spire-whorls almost smooth with obsolete axial ribbing, body-whorl same for first third, then knobs on shoulder become stronger, the last two being well raised, blunt and fairly prominent. Aperture wide and high, moderately notched below. Outer lip slightly convex, ascending, thickened and reflexed. Columella projecting well beyond outer lip, folds obscured by hard matrix but probably 4 in number. Inner lip wide-spreading, edge well defined.

Holotype in collection of New Zealand Geological Survey.

Height, 55 mm.; diameter, 27 mm.

Locality.—68, Akuaku, East Cape.

Alcithoe hurupiensis n. sp. (Plate 64, fig. 3.)

Shell large, strong, fusiform. Spire less than half height of aperture. Whorls prominently angled low down, with concave sloping shoulder; body-whorl convex below shoulder, contracting to large prominent fasciole. Suture undulating. Sculpture of strong sharp spines on shoulder-angle, 14 on early whorls, decreasing to 9 on penultimate and 7 on body-whorl; on spire tubercles are elongated into low axial ribs, but these are absent on body, the tubercles of which have steep anterior face and convex posterior one. Aperture large, channelled above, deeply and widely notched below. Outer lip thickened and slightly reflexed, ascending to shoulder-angle. Columella swollen in middle and with 4 strong well-spaced folds which decrease in height anteriorly. Inner lip spreading as thin callus well over body-whorl.

Syntypes in collection of New Zealand Geological Survey.

Locality.—Hurupi Creek, Palliser Bay.

The type material consists of two small imperfect specimens collected by the Wellington Philosophical Society excursion, 1922; and a large specimen (see Plate 64, fig. 3) with the outer lip missing, from the Geological Survey collection. It bears a locality label numbered 188 = Rotella beds, Kereru, Hawke's Bay; but the preservation and matrix are unlike other specimens in that collection and are the same as Hurupi shells. It therefore seems likely that this specimen was lost from the Palliser Bay collection and became mixed with the Kereru one. To avoid any possible trouble the large shell has not been selected as holotype.

Alcithoe arabicula n. sp. (Plate 66, fig. 4.)

Shell fairly large, broadly fusiform. Spire turreted, two-fifths height of aperture. Whorls prominently angled with broad concave shoulder; body-whorl convex below angle, contracted to prominent fasciole which is limited above by sharp ridge, outer part of fasciole corresponding to notch is concave and sunken, the inner corresponding to extremity of columella, narrowly ridged. Sculpture: penultimate whorl with 9 strong sharp tubercles on shoulder, body-whorl with 7, tubercles not extended far axially. Aperture broad, channelled above, deeply notched below. Outer lip broken, ascending, probably reflexed. Columella with 5 strong spaced plaits. Inner lip very thin and wide-spread.

Holotype in collection of New Zealand Geological Survey.

Height (estimated), 70 mm.; diameter, 35 mm.

Locality.—996, Kaawa Creek, Auckland.

The height of the shoulder above the suture is intermediate between *A. depressa* and *A. arabica*, from both of which it is distinguished by its short, broad shape, thin inner lip, and much less oblique columellar plaits.

Alcithoe lutea Marwick. (Plate 68, fig. 5.)

1924. *Alcithoe lutea* Marwick, *Trans. N.Z. Inst.*, vol. 55, p. 200, pl. 17, fig. 17 (not *Cymbiola lutea* Watson).

Locality.—Blue clays below Petane limestone, Okouawa Creek, Ngaruroro district.

Closely related to *A. detrita*, but with a shorter, broader spire. The specific name *lutea* was applied by a foolish oversight, which was pointed out *in litteris* both by Mr. Iredale and Mr. Finlay. Had Watson's species been a true *Alcithoe* a new name could be given to the fossil. but the shells are generically distinct, the former being probably a *Waihaoia (Pachymelon)*. It is not an *Alcithoe*, for it has only a shallow anterior sinus and no well-defined flattened fasciole.

Alcithoe transformis n. sp. (Plate 67, fig. 1.)

Shell moderate to fairly large. Spire conic, under half height of aperture. Nucleus large, scaphelloid, of about 3 whorls with 2 weak spirals and indistinct axials. Post-embryonic whorls with obsolete axials which finally disappear, for a space whorl is practically smooth, then low blunt tubercles appear on penultimate or body whorl, these increase quickly in strength till broad, high, and pointed; spire-whorls convex to bluntly angled; body-whorl with prominent shoulder, below which it contracts, at first very slowly, then more rapidly, to well-marked fasciole. Aperture wide, deeply notched below. Outer lip thickened, reflexed, ascending, slightly convex. Columella with 5 folds, anterior and posterior much weaker than others.

Holotype in collection of New Zealand Geological Survey.

Height, 87 mm.; diameter, 38 mm. (type): height, 117 mm.; diameter, 54 mm. (paratype).

Locality.—Kai Iwi.

This species is easily distinguished from *A. arabica* and *A. lutea* by conic (not turreted) spire, and strong tubercles of body-whorl having arisen only at a late stage following a smooth or almost smooth whorl. *A. swainsoni* occurs at Kai Iwi, but not *A. arabica*. At a lower horizon, between Ototoka Stream and Nukumaru, occurs a closely related shell with a more inflated body-whorl quickly contracted to a straightened neck and weaker tubercles; it is included in *A. transformis* for the present, but may not be a direct ancestor. Each of these knobbed forms may have been given off by *A. swainsoni* at different times.

Alcithoe swainsoni n. sp. (Plate 63, fig. 4.)

1821. *Voluta elongata* Swainson, *Exot. Conch.*, pl. 20, 21 (not of Solander, *Portland Cat.*, p. 30).

For synonymy and description see Suter's *Manual* (1913), p. 446.

As Swainson's name is preoccupied, we have a chance of fixing an available type, so the specific name *swainsoni* is proposed for a Kai-Iwi fossil in the Geological Survey collection. Unfortunately, this course was decided on too late to give a figure of the type specimen.

The division of the *arabica–swainsoni* group of shells into satisfactory species is a difficult matter. Many of the horizons in the Pliocene section exposed in the sea-cliffs from Nukumaru to Landguard Bluff have characteristic forms; but the writer lacks a large-enough series of Recent shells to determine what is the normal range of variation. Further, the significance in classification of the shoulder-nodules and tubercles has yet to be determined.

A. nukumaruensis, for example, is apparently the smooth form of *A. detrita*, but as far as known the two forms are constant and do not intergrade at this horizon. Higher in the strata, in the vicinity of Ototoka Stream, we find a smooth shell similar to *A. nukumaruensis* but with a lower spire. In these beds there is also a stout shell, *A. transformis*, with a smooth spire of moderate height and a very wide body-whorl armed with blunt nodules (Plate 67, fig. 1). From a little west of Okehu Stream to Kai Iwi Stream the common shell is the typical *A. swainsoni*. Some are smooth except for a few ribs on the first two whorls, and others develop nodules on the body-whorl. A small smooth variety has the spire shorter than the smooth shell at Ototoka Creek. In the upper part of the section is a form with a spire like *swainsoni* but with very large sharp tubercles on the body. It is somewhat like *A. depressa* in that the suture is close below the angulation, but is classed with *A. transformis* for the present.

In the lower beds at Castlecliff most of the specimens are like *swainsoni*, but many have a considerably higher spire. The spire-whorls are convex or only bluntly angled, and the body-whorl is either smooth or has low nodules. The slender shell *A. acuta* (Plate 66, fig. 3) is an extreme form which occurs here. Higher still in the sequence, at Landguard Bluff, occurs the typical *A. arabica*, with prominently-angled spire-whorls and a tuberculate body-whorl.

Whether those which have a smooth spire and a tuberculate body should be classed as *A. arabica* appears doubtful, especially since the typical form of that species has not been found in the lower beds. However, *A. lutea* from the Nukumaruan of Hawke's Bay has spire-whorls sometimes convex and sometimes angled, and differs from *A. arabica* chiefly in its higher spire.

It is possible that different races developed in different districts, and that subsequent land-movements, by removing barriers (*e.g.*, the formation of Cook Strait), enabled crossing to take place between these races, thus producing the great variety of forms.

Alcithoe larochei n. sp. (Plate 63, fig. 6.)

Shell large and strong, broadly fusiform. Spire conic, one-third height of aperture. Nucleus scaphelloid, of about 2½ rather worn whorls, apex flattened, last turn with indications of blunt axials and fine spirals. Post-embryonic whorls 5, convex on spire with flattened steep shoulder; body inflated, contracting fairly quickly to large well-defined fasciole bounded by ridge. Sculpture: first three whorls with about 18 rather low curved

axial ribs, later ones slightly angled, last two whorls smooth except for strong growth-lines. Aperture large, dilated, deeply notched below. Outer lip lightly convex, thickened, reflexed, ascending high on penultimate whorl. Columella with 4 strong folds. Inner lip thin, spread well out from aperture, not raised in fasciolar region.

Holotype in Auckland Museum.

Height, 98 mm.; diameter, 46 mm.

Locality.—Off Opotiki, 30 fathoms.

This specimen was kindly forwarded by Mr. W. La Roche, of Auckland. It resembles *Voluta (Cymbiola) lutea* Watson at first sight, but is easily distinguished by the deep anterior notch and the different outline of the spire. The species is closely related to *A. swainsoni* but is much more squat. A specimen from Castlecliff in the Geological Survey collection is fairly close to *A. larochei*, but is less inflated and has a small pad on the fasciole.

Alcithoe arabica Martyn (1784). (Plate 68, fig. 3.)

For synonymy and description see Suter's *Manual* (1913), p. 445.

The only typical specimens found fossil were from Landguard Bluff, in the highest beds of the Castlecliffian.

Alcithoe jaculoides Powell. (Plate 68, fig. 2.)

1924. *Alctihoe arabica jaculoides* Powell, *Proc. Malac. Soc.*, vol. 16, p. 108, figs. 1, 2.

Distinguished from *A. arabica* by the narrow outline, fewer spines, very high outer lip, and absence of inner-lip pad. No fossil occurrences are known.

Alcithoe acuta n. sp. (Plate 66, fig. 3.)

Shell fairly large, narrowly fusiform. Spire four-sevenths height of aperture. Nucleus scaphelloid, of 3 whorls, with a few faint spirals of which two are more distinct, crossed by numerous equally faint axials. Post-embryonic whorls 5, angled about the middle with steep shoulder; body-whorl not contracted for some distance below shoulder, then tapering quickly to well-marked fasciole which is bounded by low ridge. Sculpture: early whorls with about 13 indistinct axial ribs slightly knobbed at shoulder-angle, later axials shorten to low tubercles and number decreases to 10 or even 9. Aperture wide, deeply notched below. Outer lip dilated, thickened, slightly reflexed, slightly convex, ascending penultimate whorl almost to angle. Columella with 4 plaits, anterior one weak. Inner lip spread well out.

Holotype in collection of New Zealand Geological Survey.

Height, 113 mm.; diameter, 38 mm.

Locality.—Castlecliff (near base of series).

Alcithoe oliveri n. sp. (Plate 67, fig. 5.)

Shell very large and broad. Spire low, about one-quarter height of aperture. Spire-whorls mostly broken in type; body-whorl increasing very quickly with broad concave shoulder below which it is scarcely contracted for some distance, then tapering quickly. Sculpture: penultimate whorl with 12 fairly strong tubercles just above suture, body-whorl with 9 (perhaps 10 if complete) strong tubercles extending forward for some distance as low broad axials. Aperture large, channelled above. Outer

lip reflexed, surmounting shoulder and reaching nearly to posterior suture. Columella with 4 strong spaced folds and a fifth faint posterior one. Inner lip wide, spreading.

Holotype in Dominion Museum, presented by Mr. W. R. B. Oliver.

Height, 160 mm.; diameter, 77 mm.

Locality.—Cliffs north of mouth of Waipara River.

Resembles *A. depressa*, but is much larger and the outer lip ascends higher. The body-whorl is also relatively broader and the shoulder more nearly horizontal. The exact age is uncertain, but in the aperture of the type is a large *Eumarcia* sp. such as occurs at Waipipi and Nukumaru.

Alcithoe depressa (Suter). (Plate 67, fig. 4.)

For synonymy and description see Suter's *Manual* (1913), p. 447.

This species is distinguished from *A. arabica* by the shape of the spire, which is almost regularly conic, caused by the suture being almost on the line of the shoulder-tubercles. The spire of *A. arabica* is strongly gradate, the suture being well below the angle of the shoulder.

Localities.—Recent (type), Spirits Bay; Castlecliff.

Alcithoe lepida n. sp. (Plate 68, fig. 1.)

Shell rather small, narrowly fusiform. Spire conic, over half height of aperture. Nucleus scaphelloid, of 2½ smooth volutions. Post-embryonic whorls 5, early ones slightly convex, later ones obscurely angled below mid-point and with steep shoulder; body-whorl also with steep shoulder above obtuse shoulder-angle, below which whorl is slightly convex and contracts gradually, then straightens out to a rather long beak bearing convex fasciole not bounded by ridge. Sculpture: spire-whorls with 13 or 14 low rounded axial ribs about their own width apart, weaker on shoulder and finally not crossing it; body-whorl with 11 low pointed tubercles on shoulder, only slightly extended axially. Aperture narrow; sides subparallel, channelled above, fairly deeply notched below. Outer lip convex, ascending a little, thickened and dilated but not reflexed. Columella with 5 fairly strong plaits, decreasing in height anteriorly and posteriorly from second posterior one. Inner lip thin, not advancing far from aperture.

Holotype in collection of New Zealand Geological Survey.

Height, 56 mm.; diameter, 20 mm.

Locality.—175, one mile south of Devil's Bridge, Oamaru (= Ardgowan shell-bed).

Closely related to *A. reflexa*, but axial ribs stronger on spire and more persistent, angulation of whorls more obtuse, nodules on body-whorl weaker, anterior notch slightly shallower and aperture not so dilated. It is therefore not so advanced as, and perhaps directly ancestral to, *A. reflexa*.

Alcithoe reflexa n. sp. (Plate 68, fig. 6.)

Shell of moderate size, fusiform, thin. Spire slightly under half height of aperture. Nucleus narrow, scaphelloid, of about 2½ smooth whorls. Post-embryonic whorls 5½, first two with almost straight outlines, third slightly convex in lower part, fourth obtusely angled about mid-point; body-whorl with concave fairly broad shoulder, below which it contracts scarcely at all for a distance, then fairly quickly, finally straightening out again before reaching well-marked fasciole which is rather flattened and

sunken along outer part corresponding to notch, but with ridge on inner part formed by projecting columella. Sculpture: spire-whorls with many obsolete axial ribs blending with growth-lines, about 13 on penultimate whorl; on body-whorl 8 strong sharp knobs are developed on shoulder but do not extend far axially. Aperture dilated, broadly angled above, deeply notched below. Outer lip convex, ascending half-way up penultimate whorl, conspicuously reflexed. Columella with 5 folds, all but anterior strong, second posterior one is highest, columella projects well below outer lip and is curved backwards. Inner lip thin, spreading.

Holotype in collection of Mr. H. J. Finlay.

Height, 64 mm.; diameter, 27 mm.

Localities.—Pukeuri (type); Rifle Butts, South Oamaru.

Alcithoe finlayi n. sp. (Plate 69, fig. 1.)

Shell of moderate size and strength, elongate, biconic. Spire about four-fifths height of aperture. Nucleus scaphelloid, of 2 or 3 smooth whorls. Post-embryonic whorls 4½, height more than half diameter, first ones lightly convex, others bluntly angled below middle, with long sloping slightly concave shoulder; body-whorl only slightly convex, below shoulder contracting gradually to large fasciole which is bounded by low ridge. Suture somewhat undulating. Sculpture of about 12 low blunt tubercles on shoulder of each whorl, on body they are only slightly elongated anteriorly, but on spire-whorls they reach anterior suture, on first two conch-whorls they also reach posterior suture. Aperture hastate, channelled above, deeply notched below. Outer lip thin and rounded, slightly convex, retreating below, edge not reflexed, ascending only slightly towards shoulder. Columella with 4 strong oblique folds, decreasing in height anteriorly. Inner lip spread as a thin glaze for a moderate distance from aperture.

Holotype in collection of Mr. H. J. Finlay.

Height, 60 mm.; diameter, 22 mm.

Locality.—Shell-bed, Target Gully, Oamaru. (= *Fulgoraria gracilis* of Suter, 1921, p. 81.)

This species is the commonest Volute in the shell-bed.

Alcithoe scopi n. sp. (Plate 69, fig. 2.)

Shell of moderate size, strong, fusiform. Spire a little over half height of aperture. Nucleus scaphelloid, very large, of 2½ depressed whorls. Post-embryonic whorls 4½, height less than half diameter; spire-whorls slightly convex; body-whorl with fairly long sloping shoulder, bluntly angled, lightly convex and contracting below to large only slightly raised fasciole. Sculpture on spire-whorls of 10–12 axial ribs with weak nodule, low down, forming obscure shoulder-angle; axials obsolete on penultimate and body whorl, so that their number cannot be determined. Suture undulating. Aperture hastate, channelled above, widely and moderately deeply notched below. Outer lip slightly convex, retreating below, edge rounded not reflexed, ascending only slightly on penultimate whorl. Columella with 4 strong oblique plaits, decreasing in height anteriorly. Inner lip thin, restrained.

Holotype in collection of New Zealand Geological Survey.

Height, 53 mm.; diameter, 21 mm.

Locality.—Shell-bed, Target Gully, Oamaru. (= *Fulgoraria gracilis* of Suter, 1921, p. 81.)

Closely related to *A. finlayi*, but with lower spire and whorls and much larger protoconch; also the sculpture becomes obsolete at an early stage, though this is sometimes seen in examples of *A. finlayi*.

Alcithoe neglecta n. sp. (Plate 66, fig. 7.)

Shell small, fusiform, solid. Spire conic, half height of aperture. Nucleus scaphelloid, of about 3 smooth whorls. Post-embryonic whorls 4, obtusely angled rather below middle on spire and with steep shoulder; body-whorl slightly convex below shoulder, contracting to fasciole which is somewhat depressed on outer half but ridged on inner and separated by low ridge from base of body-whorl. Sculpture: spire-whorls with 16 or 17 axial ribs per whorl; ribs rounded, very low, raised into weak knob forming shoulder about one-third across whorl from anterior suture, and reaching anterior suture but scarcely as far as posterior one; body-whorl with 9 low rounded axially elongated knobs on first two-thirds of volution, on remaining third they are obsolete. Aperture high, triangular, channelled above, widely and somewhat shallowly notched below. Outer lip convex, thick, not reflexed, descending slightly for a short distance but previously ascending by same amount. Columella with a convex pad surmounted by 5 columellar folds, space between posterior two almost filled up, folds decreasing in strength anteriorly. Inner lip spreading well out from aperture.

Holotype in collection of New Zealand Geological Survey.

Height, 47 mm.; diameter, 20 mm.

Localities.—Shell-bed, Target Gully; Rifle Butts, Oamaru (more attenuated than type).

Alcithoe solida n. sp. (Plate 69, fig. 3.)

Shell rather small but very heavy, biconic. Spire two-thirds height of aperture. Nucleus depressed, scaphelloid, of 3 smooth whorls with large apex. Whorls 6, including nucleus, on spire they are bluntly angled about middle of whorl; body-whorl with a slightly concave sloping shoulder, below which it is lightly convex and contracted to fasciole, which is not raised. Suture undulating. Sculpture of about 12 strong axial ribs per whorl, they extend from suture to suture on spire, being bluntly angled on the shoulder-angle and twisted forward above, ribs persist well down over body but do not reach fasciole; towards aperture ribs inclined to die away; some specimens have whole body-whorl almost smooth. Aperture long and very narrow, channelled above, deeply notched below. Outer lip thin and rounded, slightly convex, somewhat inclined backwards from suture. Columella with 4 strong spaced plaits. Inner lip spread as thin callus a short distance over body-whorl.

Holotype in collection of New Zealand Geological Survey.

Height, 45 mm.; diameter, 21·5 mm.

Localities.—1133, coast north of Mimi Stream, Waitara Survey District; 52, White Cliffs, Taranaki (= *Miomelon corrugata* (Hutt.) and var. B of Suter, 1921, p. 22); 3 chains towards Tongaporutu from Okau junction, Mimi Survey District.

The single specimen from the latter locality is much more slender than the typical species. As it occurs in the Tongaporutuan, whereas the Mimi Stream shells are Urenuian, this may have stratigraphical significance.

Alcithoe corrugata (Hutton).

1873. *Voluta (Lyria) corrugata* Hutton, *Cat. Tert. Moll*, p. 7.
1914. *Lapparia corrugata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 2*, p. 27, pl. 2, figs. 4 *a*, *b* (in part).
1914. *Cymbiola (Miomelon) corrugata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 87.
1918. *Miomelon corrugata* (Hutton): Suter, *Alph. List of N.Z. Tert. Moll.*, p. 19.

Hutton's type should never have been described. The outer surface is completely weathered away, and the ruin conveys only a rough idea of the original details of the shell. Enough remains to show that Suter was mistaken in synonymizing his *Lapparia parki* with *V. corrugata*. The body is very broad, and the ribs, which have a strong twist, extend across it. The angle of the spire is 57°, while that of *L. parki* is 48°. Hutton's type resembles fairly closely the shell described in this paper as *Alcithoe solida*, but it is slightly bigger and has a few more ribs. Until some topotypes have been secured, however, the best course is to ignore the species.

Alcithoe exigua n. sp. (Plate 69, fig. 4.)

Shell small, fusiform. Spire slightly turreted, two-thirds height of aperture. Spire-whorls bluntly angled about middle; body-whorl rounded not inflated, tapering fairly regularly to convex well-marked fasciole. Sculpture: spire-whorls with about 12 weak axials, slightly tubercled at shoulder, almost dying out towards sutures; on body-whorl axials have become obsolete. Aperture moderate, deeply notched below. Outer lip sinuous, thickened, not reflexed, ascending. Columella with 4 strong folds, anterior end twisted. Inner lip rather thick, well spread.

Holotype in collection of New Zealand Geological Survey, deposited by Mr. R. S. Allan.

Height, 58 mm.; diameter, 21·5 mm.

Localities.—Sands at boat-landing, Nukumaru; one-quarter mile west of Ototoka Stream (between Okehu and Nukumaru); 231, McLean's, Ngaruroro River.

The specimens from the last two localities are much worn, so the identification is doubtful. Distinguished from *A. gracilis* by the higher and more acute spire, more calloused aperture, and twisted columella. The type is not unlike a small *A. nukumaruensis*, but is comparatively narrower, and the ribbing on the spire is probably much stronger.

Alcithoe brevis n. sp. (Plate 69, fig. 6.)

Shell rather small, very broadly fusiform, strong. Spire turreted, two-thirds height of aperture. Nucleus large, scaphelloid, of 2 smooth volutions, upper one much flattened. Post-embryonic whorls 4½, first lightly convex, later ones with concave sloping shoulder gradually increasing in strength, angulation being about middle of spire-whorls; body-whorl contracting fairly quickly to anterior end; fasciole well marked, bounded by ridge. Sculpture: whorls with 13–16 strong rounded axial ribs with equal interstices, ribs decrease suddenly in strength above angle and are quite weak across shoulder, on body-whorl they persist well down towards fasciole but are quite low and sometimes become obsolete. Aperture moderately notched anteriorly, columellar side scarcely projecting. Columella with 4 strong folds, anterior weakest; between second and third folds of a paratype is a weak secondary fold. Inner lip rather thick, edge well defined.

Holotype in collection of New Zealand Geological Survey, deposited by Dr. P. Marshall.

Height, 39 mm.; diameter, 19 mm.

Locality.—81, Castle Point.

Alcithoe subgracilis n. sp. (Plate 69, fig. 9.)

Shell rather small, fusiform. Spire turreted, about three-fifths height of aperture. Nucleus scaphelloid, of about 2 whorls with 3 or 4 weak spaced spirals crossed by equally weak axials. Post-embryonic whorls 4, angled slightly above middle, with concave sloping shoulder and perpendicular sides; body-whorl also with concave sloping shoulder and prominent angle, below which it contracts with trifling inflation to well-marked fasciole. Sculpture of 15 or 16 strong axial ribs, much weaker on shoulder but stretching well down body-whorl. Aperture moderate, deeply notched below. Outer lip thickened, slightly convex, ascending. Columella with 4 plaits. Inner lip moderately enamelled and extending.

Holotype in collection of New Zealand Geological Survey.

Height, 40 mm.; diameter, 16 mm.

Localities.—736, clays below limestone, Petane; many localities in the Petane beds of the Ngaruroro River district; 1040, Twaite's Cutting, Martinborough district.

Alcithoe mackayi n. sp. (Plate 69, fig. 7.)

Shell rather small, narrowly fusiform. Spire turreted, nearly as high as aperture. Nucleus flattened, scaphelloid, of about 2 smooth whorls. Post-embryonic whorls 4½, angled about middle, with slightly concave sloping shoulder persisting on body-whorl, which contracts gradually to conspicuous fasciole. Sculpture of strong axial ribs with wider interstices, ribs reach from suture to suture but are very weak on base of body-whorl, they decrease in number from 15 on early whorls to 11 on body-whorl, and are somewhat tubercular on angle of shoulder. Aperture moderate, deeply notched below. Outer lip slightly thickened, ascending a little. Columella with 4 plaits decreasing anteriorly. Inner lip well calloused.

Holotype in collection of New Zealand Geological Survey.

Height, 51 mm.; diameter, 18 mm.

Locality.—191, Blue clays, Shrimpton's, Ngaruroro River.

Probably an offshoot from *A. subgracilis*, from which it differs in being narrower, higher in the spire, and in having stronger axials. It is the forerunner of *A. hedleyi*, which marks a further advance in having a smooth cylindrical body-whorl.

Alcithoe gracilis Swainson, 1821. (Plate, 69, fig. 5.)

For synonymy and description see Suter's *Manual* (1913), p. 448.

The line of descent of *A. gracilis* has for long been separated from that of *A. arabica*, and probably came through *A. finlayi* n. sp., of Awamoan age.

The height of the spire varies from less than half to about two-thirds that of the aperture. Sometimes the shoulder-nodules are present on the body-whorl, but often they are quite obsolete.

Localities.—Recent (type); Castlecliff (plentiful); Kai Iwi; many localities in blue clays below Petane limestone, Ngaruroro River, grading into *A. subgracilis*.

Alcithoe hedleyi Murdoch and Suter. (Plate 69, fig. 8.)

1906. *Fulguraria (Alcithoe) hedleyi* M. & S., *Trans. N.Z. Inst.*, vol. 38, p. 288, pl. 23, figs. 20, 21.

This is a rare shell, not known fossil. The body-whorl is cylindrical and almost the same in diameter as penultimate whorl. The fasciole is well marked, outer half being depressed, bounded above by sharp ridge and below by broad rounded ridge occupying lower half of fasciole.

Alcithoe dilatata n. sp. (Plate 65, fig. 2.)

Shell small, solid, broadly fusiform. Spire two-fifths height of aperture. Nucleus damaged, apparently scaphelloid. Post-embryonic whorls 4, with sloping concave shoulder; spire-whorls angled just above suture; body-whorl convex below shoulder, retreating somewhat quickly to large prominent fasciole which is bounded above by ridge. Suture undulating, channelled at aperture. Shoulder with 8–10 sharp strong tubercles per whorl, those on spire sometimes on line of suture; they are not laterally compressed but extend anteriorly half-way across body-whorl as low axial ribs. Aperture hastate, channelled above, deeply and widely notched below. Outer lip convex, thickened, especially posteriorly; very slightly reflexed, ascending quickly on last quarter-whorl and finally bent over to form deeply channelled suture. Columella sometimes decidedly bent to rear, with 4 strong rather close folds, anterior one very weak. Inner lip with smooth callus extending well out on body and with thick pad on parietal wall.

Holotype in collection of New Zealand Geological Survey.

Height, 34·5 mm.; diameter, 17·5 mm.

Locality.—Basal sandstones, Hurupi Creek, Palliser Bay.

Alcithoe parva n. sp. (Plate 65, fig. 6.)

Shell small, broadly fusiform. Spire two-fifths height of aperture. Spire-whorls angled just above suture, with long, sloping, slightly concave shoulder; body-whorl convex below shoulder and contracting rather rapidly to prominent fasciole, which is bounded above by ridge. Suture undulating. Sculpture of 13 axial ribs, very weak on sloping shoulder but raised into low tubercles on angle; on body-whorl tubercles are sharp and fairly strong, and ribs tend to become obsolete. Aperture suboblong, channelled above, deeply and widely notched below. Outer lip thickened, slightly reflexed, ascending and cemented to penultimate whorl half-way between shoulder-angle and suture above. Columella with 5 well-separated folds. Inner lip with thick wide-spreading callus.

Holotype in collection of New Zealand Geological Survey.

Height, 37 mm.; diameter, 18 mm.

Locality.—996, Kaawa Creek.

Incertae sedis.

Alcithoe residua Finlay. (Plate 70, fig. 3.)

1926. *Alcithoe residua* Finlay, *Trans. N.Z. Inst.*, vol. 56, p. 249, pl. 55, fig. 5.

The nucleus is almost caricelloid, the initial whorl being high conoid. The sculpture of low axial ribs crossed on the early whorls by spiral sculpture, and the lack of angulation, seem to show relations closer to *Spinomelon* than to *Alcithoe*. The species, however, can remain under the latter until the generic position is more certain.

Locality.—Otiake.

Alcithoe gatesi new name. (Plate 70, fig. 7.)

1920. *Fulguraria morgani* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 52, p. 133, pl. 7, figs. 12, 12*a*, 12*b* (not of Cossmann and Pissarro).
1923. *Fulguraria morgani* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 54, p. 125 (in part), pl. 15, figs. 1, 2, 3.

Cossmann and Pissarro (1905, p. 76, pl. 14, figs. 13, 14) have already described a French fossil under the name *Fulguraria (Alcithoe) morgani*, so a new name must be given to the New Zealand species.

Owing to the obsolescence of axial sculpture on nearing the aperture, and for other reasons discussed below, the type of *A. gatesi* is considered to be an adult and the large specimens figured by Marshall and Murdoch (1923, p. 14, figs. 1, 2) to be a new species, which has consequently been given the name *A. whakinoensis*.

Localities.—Waipipi; Whakino; 875, coast, half-mile west of Waingongoro River.

Alcithoe whakinoensis n. sp. (Plate 70, fig. 6.)

1923. *Fulguraria morgani* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 54, p. 125 (in part), pl. 14, figs. 1, 2.

Shell large. Spire about equal to aperture. Whorls bluntly angled above middle, and with steep scarcely concave shoulder; body with more excavated shoulder, below which it tapers convexly to very prominent convex fasciole curved inwards below. Sculpture of 16–20 strong axial ribs on spire-whorls, extending from suture to suture but weaker on shoulder and projecting as rudimentary tubercles on angle; body with strong tubercles on periphery, axials obsolete. Suture undulating. Aperture wide, deeply notched below. Outer lip dilated, thickened and reflexed, ascending. Columella with 5 plaits. Inner lip thin, well spread out.

Holotype in Wanganui Museum.

Height, 112 mm.; diameter, 38 mm.

Localities.—Whakino; Waipipi.

This large shell was thought by Marshall and Murdoch to be the adult of their *A. morgani* (= *A. gatesi* new name); but several important points indicate the specific separation of the large from the small—or, at least, many of the small shells. Thus on the type and other specimens of *A. gatesi* the ribs become obsolete near the aperture and are replaced by numerous strong growth-lines, also the outer lip ascends noticeably. The juvenile specimen figured by Marshall and Murdoch (1920, pl. 7, fig. 12*b*) belongs to the new species *A. whakinoensis*; the whorls are considerably larger and notably higher than those of *A. gatesi* at the same stage. The separation of two species explains the comparative rarity of the larger shells.

Alcithoe haweraensis n. sp. (Plate 70, fig. 5.)

Shell of moderate size, fusiform. Spire turreted, three-fifths height of aperture. Spire-whorls with sloping convex shoulder, prominently angled, below which are perpendicular sides; body-whorl inflated with angulation and concavity becoming obsolete on last half; base contracted rather quickly to well-marked fasciole. Sculpture of 13–14 strong narrow axial ribs, which become suddenly very weak above angle and thus leave an almost smooth shoulder; on body-whorl ribs are at first more numerous

but become obsolete on last half-turn, their place taken by strong growth-lines. Aperture somewhat dilated, narrowed above, deeply notched below. Outer lip slightly convex, thickened, reflexed, ascending a little. Columella with 5 strong spaced plaits, anterior and posterior weakest. Inner lip spreading well out.

Holotype in collection of New Zealand Geological Survey, deposited by Mr. R. S. Allan.

Height, 79 mm.; diameter, 33 mm.

Localities.—Hawera (type); Waipipi.

Differs from *A. gatesi* in the fewer and stronger ribs, almost smooth shoulder, inflated body-whorl, and 5 plaits on columella, and from *A. whakinoensis* in the much shorter spire.

A specimen from Waipipi is most irregularly ribbed and covered by strong growth-lines. It may be a pathological specimen, but the holotype shows a similar development on the last half-whorl, so perhaps the species is a gerontic one.

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Myalinidae from the Jurassic of New Zealand.

A New Genus and a New Species.

By J. Marwick, M.A., D.Sc., New Zealand Geological Survey.

[*Abstract read, by permission of the Director of the New Zealand Geological Survey, before the Wellington Philosophical Society, 8th October, 1924; received by Editor, 22nd December, 1924; issued separately, 13th March, 1926.*]

Plate 71.

Aucella plicata Zittel. (Plate 71, figs. 7, 8, 9.)

1864. *Aucella plicata* Zittel, *Reise der "Novara,"* Geol. Th., 1 Bd., 2 Abt., p. 32, pl. 8, figs. 4 *a, b, c.*

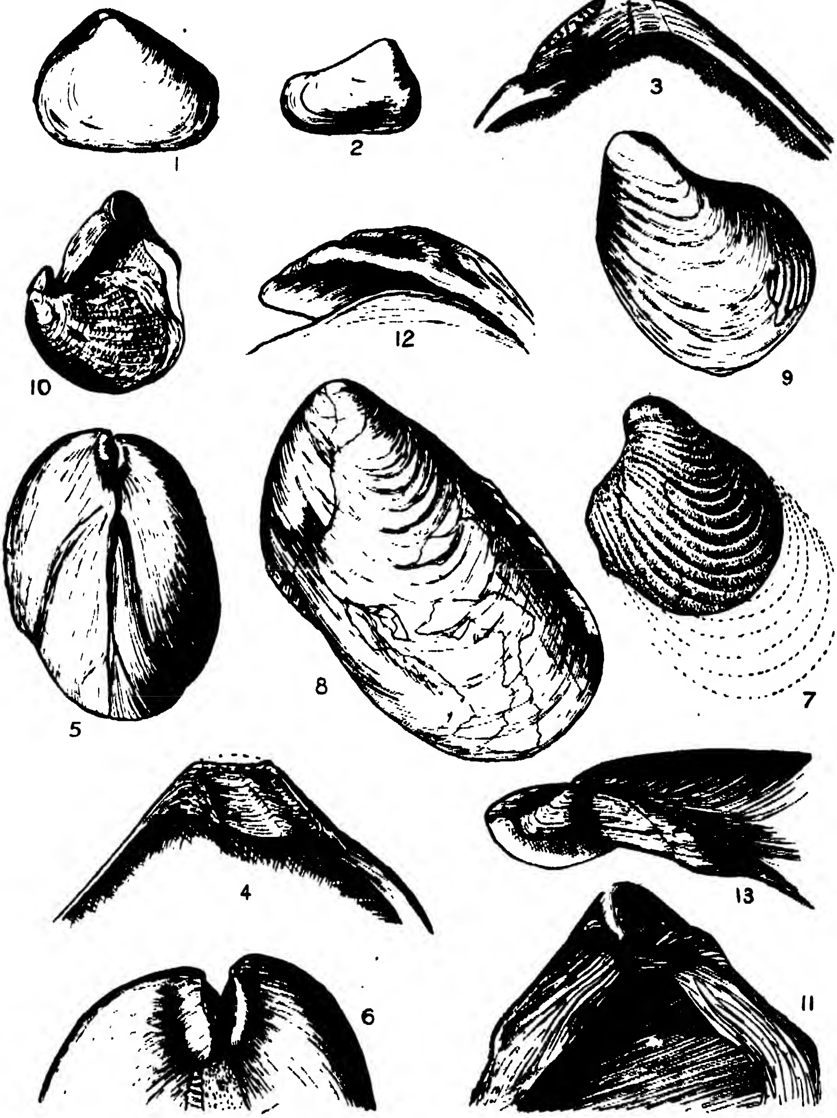
1911. *Aucella plicata* Zittel: Boehm, *Neu. Jarb. f. Min., Geol., u. Pal.*, Bd. 1, p. 11.

The Jurassic rocks of New Zealand contain several species of *Aucella*, one of which, *A. plicata*, was described by Zittel from specimens collected at Waikato South Head by Hochstetter. Many years later Suter collected fossils for G. Boehm from the shores of Kawhia Harbour. Among these were specimens of a small *Aucella* with well-marked radial ribs from Kowhai Point and "Captain King." Boehm classed these under *A. plicata*, stating that the original of Zittel's figure also showed definite radials. Still, he was by no means certain that the Kawhia shells were conspecific with the Waikato ones, for he says (1911, p. 13), "Es bleibe dahingestellt, ob diese Vereinigung aufrecht zu erhalten ist und ob sich spaeter nicht mehrere verschiedene Spezies ergeben werden. Warum eilt denn derartiges so sehr?" His principal object was to prove that a true *Aucella* did occur in New Zealand, for Pompeckj had expressed doubt on the matter; consequently he was not greatly concerned with the finer specific divisions of his material.

Trechmann (1923, p. 265), who collected at Kawhia and had material sent to him from Waikato, stated definitely that his specimens from the former place (Kowhai Point) were specifically different from those of the latter. With considerable hesitation he accepted Boehm's Kawhia specimens as the true *A. plicata*, and placed the Waikato ones under *A. spitiensis* Holdhaus and *A. spitiensis* var. *extensa* Holdaus. A comparison of Zittel's figures with specimens from Kawhia Harbour or with Boehm's and Trechmann's excellent figures does not bear out this conclusion.

The arrangement of the concentric ornamentation on Zittel's figure 4*a* shows that a great portion of the posterior and ventral regions of the shell is missing. The original outlines must have been somewhat like that indicated in Plate 71, fig. 7. In size and shape this is well matched by specimens collected by Dr. J. Henderson from conglomerates at Waiharakeke Bridge, Kawhia Survey District, and Mangati Valley, Whaingaroa Survey District (Plate 71, figs. 8, 9). The original of fig. 8 has a narrow beak, but it is strongly incurved like the others, and so is concealed when the shell is in a position to show its maximum length.

Of several hundred specimens in Geological Survey collection 267, Waikato South Head, none resembles the short, thick Kawhia shell, nor did



FIGS. 1, 2.—*Pseudaucella marshalli* (Trechmann), × 1.
FIGS. 3, 4.—Right and left hinges of *P. marshalli*. × 4. Original of fig. 4 has hardly any ear, but the groove can be seen.
FIG. 5.—Front view of fig. 1. × 2.
FIG. 6.—Front view of another specimen. × 4.
FIG. 7.—*Aucella plicata* Zittel; after Zittel; dotted lines added.
FIGS. 8, 9.—*Aucella plicata* Zittel; Mangati Valley; internal casts with fragments of shell adhering. × 1.
FIG. 10.—*Aucella boehmi* n. sp; holotype. × 1.
FIG. 11.—*Aucella boehmi*. Left valve of holotype seen from below. × 3.
FIG. 12.—*Aucella boehmi*. Hinge of right valve seen from front, showing concave ear with ligamental area above. × 4.
FIG. 13.—*Aucella boehmi*. Same seen from above. × 4.

Marshall or Bartrum find such a form there. All are close to the type figured by Trechmann (1923, pl. 14, figs, 5, 6, 7), who, moreover, mentions (1923, *cit.*, p. 268) "two left valves and a right valve of a form indistinguishable from *A. blandfordiana* Holdhaus." This is significant in view of Holdhaus's statement (1913, p. 405) that he had seen the types of *A. plicata* and considered the species "very closely allied to *A. pallasi* and *A. blandfordiana.*"

The matrix of the Waikato South Head fossils is an argillite, and the left valves are more or less distorted owing to shrinkage of the beds on the expulsion of contained water. Their original shape must have been very like that of the Mangati shells (Plate 71, figs. 8, 9), which, being in a conglomerate, were not deformed. The shells compared by Trechmann with *A. blandfordiana* are therefore probably typical *A. plicata*, and the narrower forms varieties. Whether these are identical with any of the Spiti species is difficult to say; but they should be listed as *A. plicata* or varieties of it, for, of course, that specific name has priority.

The species from Kawhia Harbour therefore requires a name, so *Aucella boehmi* n. sp. is proposed for it.

Aucella boehmi n. sp. (Plate 71, figs. 10–13.)

1911. *Aucella plicata* Zittel: Boehm, *Neu. Jahrb. f. Min., Geol., u. Pal.*, Bd. 1, p. 18, pl. 2, figs. 1, 2 *a–c*, 3 *a, b*; 4 (not of Zittel).

1923. *Aucella plicata* Zittel: Trechmann, *Q.J.G.S.*, vol. 79, p. 266, pl. 17, figs. 4–8 (not of Zittel).

Shell small, inequivalve, thick, obliquely ovate; inflation variable. Left valve moderately to greatly inflated; beak narrow, strongly incurved and twisted, anterior end short, straightened, descending; ventral margin straight and oblique in front, then curving regularly to meet posterior margin, which is convex below, straightened and oblique above; dorsal margin short and straight or lightly convex, meeting posterior margin in blunt angle. Right valve flattened with long, strong anterior ear partly supporting ligamental area and with deep concavity facing left valve forming byssal notch in outer upper margin of ear. Sculpture of narrow concentric bands slightly raised along outer margin, and bearing fine radial ribs. Hinge edentulous. Ligamental area fairly broad, extending from the beak posteriorly, slightly concave in left valve but with no central pit or depression; in right valve area is well marked, bounded on posterior side by narrow ridge, raised in a rounded ridge on anterior ear; centre of area traversed by well-defined though shallow triangular ligament-pit.

Holotype (a complete individual) in collection of New Zealand Geological Survey.

Maximum height (left valve), 25 mm.; maximum breadth, 18 mm.; inflation, 11 mm.

Locality.—1193, point west of Waikiekie Stream, Kawhia Harbour.

A shell figured by Broili (1924, pl. 2, fig. 10) as ? *Pseudomonotis* sp. from the Oxford of Vogelkop, north-west New Guinea, has a strong resemblance to flat variations of *A. boehmi*. The radials, however, are more spaced on the New Guinea shell.

PSEUDAUCELLA n. gen.

Shell rather small, triangular, equivalve, inflated, bent quickly inwards near margins. Beaks anterior. Escutcheon long, broad, concave. Lunule

shallow, without definite boundary. Ventral margin generally concave. Each valve has a narrow anterior ear separated from lunule by a groove; ear of left valve of variable size, formed by thickening of margin; ear of right valve somewhat larger, groove deeper, and with small notch byssal in margin. Surface smooth except for some prominent concentric growth-stages towards margin. Hinge edentulous. Ligamental area of moderate size, obliquely triangular to trapezoid, with a broad often ill-defined central pit. Muscular impressions not visible in any of the specimens. Valve-margins thin, smooth.

Type: *Aucella marshalli* Trechmann. (Plate 71, figs. 1–6.)

Trechmann (1923, p. 269) recognized the unusual characters of this shell, and thought it probably represented a new genus, perhaps related to his *Hokonuia*. Additional material collected from Kawhia by Henderson and Grange throws further light on these peculiarities, and confirms Trechmann's opinion that a new generic division is required. The anterior ear of the right valve is but little stronger than that of the left, and so is not nearly so specialized as that of *Hokonuia* or *Aucella*. The size of the left ear is, however, more variable than that of the right; occasionally it is scarcely developed.

There is little or no difference in the inflation of the valves, apparent inequalities of one or the other being due to accidents of pressure during fossilization. The shape is extremely variable, and, as there is generally considerable deformation due to rock-changes, the original outline is difficult to make out. Most of the specimens have beaks about the anterior fourth, a strongly concave escutcheon, and a concave ventral margin; some, however, have almost median beaks, a shallow escutcheon, and straight ventral margin. From its occurrence uniformly low in the Jurassic strata this shell is most useful as a zone-determiner.

Localities.—1191, 1195, 10 chains south along coast from Ururoa Point, Te Maika Peninsula, Kawhia Harbour; Awakino Valley (Henderson and Ongley, 1923, p. 20); north of Sandy Bay, Nugget Point (Trechmann, 1923, p. 269).

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Molluscan Fauna of the Waiarekan Stage of the Oamaru Series.

By J. MARWICK, M.A., D.Sc., New Zealand Geological Survey.

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Plate 72.

IN the winter of 1921 the writer was enabled to make a collection of marine fossils from the Waiarekan tuffs between Lorne (formerly Whitstone) and Enfield, north Otago. The exact spot had been accurately described in a letter to Mr. P. G. Morgan by Mr. Thomas Esdaile, formerly a resident of the district, but now of Kalgoorlie. The fauna proved to be so obviously different from the one usually considered as typical of the Waiarekan stage that it led to a critical examination of the Esdaile collections in the possession of the Geological Survey. The results were startling. The shells from

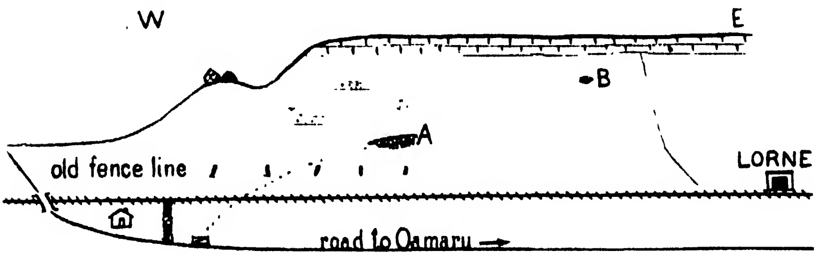


FIG. 1.—Diagrammatic sketch of area from Lorne westward to railway-crossing. Ototaran limestone at top of escarpment, Waiarekan tuffs below.

(Scale: About 1 in. to 6 chains.)

locality 630 were found to be, in all probability, from the Waihao greensand at McCullough's Bridge (Marwick, 1924, p. 280), and had been wrongly attributed to Mr. Esdaile; those from locality 831, the true Esdaile collection, can be divided into at least four groups, each with a distinct matrix and fauna. Further, most of the identifications made by Suter (1921, p. 79) are quite wrong.

Therefore, to give the Waiarekan stage a definite palaeontological basis, it is here proposed that the hillside immediately west of Lorne be taken as the type locality. This will probably result in the limiting of the Waiarekan stage to the period represented by the tuffs, a proceeding already suggested by the author of the stage (Thomson, 1916, p. 35).

The collection was gathered from two spots—(A) the top of a tilted ledge outcropping from the grass-covered talus about 50 ft. above the level of the railway and several chains north of it, between a quarter and half a mile west of Lorne Railway-station; (B) in a small niche in the face of the hill some 200 yards farther east and about 100 ft. below the summit of the limestone-crowned escarpment.

The fossils occur in a thin band of volcanic conglomerate, the pebbles of which are up to 3 in. in diameter, some completely rounded, but others with only the sharp edges smoothed off. These are set in a characteristic green matrix consisting of calcareous, pebbly, tuffaceous clay, crowded with Foraminifera. The outcrop at A is identical in appearance with that at B, and from its occurrence is probably part of a large fallen block.

In addition to the mollusca described below, several brachiopods and a small echinoderm were obtained. The former are in the hands of Dr. J. A. Thomson, and the latter has been sent to Dr. H. L. Hawkins, of Reading.

Revision of Suter's List from Loc. 831, Cave Valley and Upper Waiareka Valley (1921, p. 79).

This collection is a heterogeneous one; but the specimens from the type locality are easily distinguishable by the peculiar light-green colouring of their matrix. In the following lists Suter's identifications are given first, the serial numbers indicating their position on his list.

(*a*.) Lorne. Matrix of green foraminiferal calcareous clay:—

5. *Corbula canaliculata* = *Eucrassatella* sp., probably *E. media* n. sp. Fragmentary cast. The curvature of the beaks shows that we are dealing with a left valve, which in *C. canaliculata* is almost smooth, not ribbed as this shell is.
6. *Corbula* sp. = *Fossularca januaria* n. sp. The matrix had not been cleared away from the hinge, and the back of the shell certainly looked like a *Corbula*.
7. *Crassatellites obesus* = *Eucrassatella media*.
10. *Cymatium minimum* = *Austrotriton* n. sp. Spire not so high as *minimum*, and only about half the number of ribs of *A. maorium* Finlay.
13. *Fusinus solidus* = *Fusinus* n. sp. Closely related, but with 8 axial ribs instead of 12. Most of the specimen is an internal cast, so it is too poor for specific description. Another specimen of different matrix (*b*) was with this one.
14. *Glycymeris globosa* = *Glycymeris lornensis* Marwick.
18. *Mitra inconspicua* = *Vexillum lornense* n. sp. There are only 3 plaits on the columella, and the surface has obsolete cancellate sculpture. *M. inconspicua* is smooth and has 4 columellar plaits.
20. *Ostrea subdentata* = *Ostrea* n. sp. cf. *mackayi* Suter, but of more irregular growth and thicker.
23. *Protocardia pulchella* = *Nemocardium semitectum* n. sp.
26. *Serpulorbis sipho* = *Siliquaria senex* n. sp.
32. *Turritella carlottae* = *T. lornensis* n. sp.
34. *Venericardia difficilis benhami* = *Venericardia benhami* (Thomson).
35. *Venericardia* sp. = *V. benhami*. One specimen of a different species is set in matrix C.

(*b*.) Whitish calcareous matrix, sometimes richly foraminiferal, sometimes with considerable tufaceous matter (perhaps from more than one locality):—

1. *Cantharidus fenestratus* = indeterminable. The specimen is a distorted internal cast, so it is difficult, if not impossible, to make certain of its relationship.
2. *Capulus* sp. = an internal cast of a shell much more coiled than *Capulus australis*. It might be from a high-beaked *Venericardia*.
4. *Cardium* sp. = *Venericardia* sp. A small shell of 10 mm. diameter with about 20 ribs.
12. *Daphnella* sp. = *Acamptochetus* n. sp. Two distorted whorls only.
13. *Fusinus solidus* = internal cast with smooth whorls, so not *solidus*.
15. *Hemiconus ornatus* = internal cast of *Conospira* sp. Indeterminable.
16. *Leda semiteres* = *Nuculana* sp. A small shell, 5 mm. long, closed and damaged.
17. *Lima paleata* = *Lima paleata*.
19. *Mytilus huttoni* = *Lima?* Distorted cast of closed individual; 21–25 strong ribs with equal interstices.
22. *Pleurotomaria tertiaria* = internal cast of a shell, 40 mm. in diameter, 35 mm. high. May be a *Pleurotomaria*, but no sign of slit.
24. *Protocardia sera* = *Venericardia* casts, strongly asymmetrical and incurved.
27. *Siphonalia conoidea* = *Aethocola* sp. A fragment with 15 ribs on body, and strong spiral cords with wide interstices containing weak secondaries.

(*c*.) Coarse whitish-brown sandstone (? locality):—

28. *Struthiolaria cincta* = *Monalaria concinna* (Suter). The specimen is almost wholly a cast, but the characteristic winged aperture is plainly seen.
29. *Struthiolaria minor* = *Monalaria concinna* (juvenile).
35. *Venericardia* sp. = a small *Venericardia* of 8 mm. diameter; number of ribs uncertain, but apparently less than 20.

(*d*.) Dark-brown rusty sandstone, probably from vicinity of Windsor or Tapui:—

3. *Cardium patulum?* = *Cardium* sp. with about 40 ribs on the front and middle of the disc; the ribs do not show plainly on the posterior. *C. patulum* has well over 100 ribs, and is probably a *Protocardia* (*Nemocardium*).
9. *Cylichnella enysi* = *Bulinella* n. sp. Casts not so cylindrical as *enysi*.
11. *Cytherea* sp.? = *Eucrassatella* sp. of quite characteristic shape.
21. *Panope orbita* = *Panope worthingtoni*. Longer and more regular than *P. orbita*.
25. *Psammobia lineolata* = a cast showing part of hinge of an equilateral shell with long well-developed laterals; probably *Mactra*.
29. *Struthiolaria minor* = *Monalaria concinna* (juvenile).
30. *Struthiolaria tuberculata concinna* = *Monalaria concinna*.
31. *Tellina eugonia?* = *Tellina* n. sp. 25 mm. by 16 mm. Beaks only 11 mm. from posterior end; posterior dorsal margin well curved.

(*e.*) 33. *Turritella concava* = *Turritella* n. sp. The specimen is identical in preservation and other features with a common unnamed shell in the greensands at McCullough's Bridge, Waihao. It is almost certain that the specimen came from there and was accidentally included with the Waiarekan collection. It bears the label "*Turritella pagoda*" in Suter's writing. The change was probably made because the neanic shell of *T. concava* has a strong spiral keel. It is nevertheless easily distinguished from *T. pagoda*. The specimen we are dealing with does not belong to either species.

Since localities (*c*) and (*d*) contain *Monalaria concinna*, which indicates a Bortonian age, they probably are from the marine sands overlying the Ngaparan coal-measures.

Fauna of the Waiarekan Stage, restricted, as suggested by Thomson (1916, p. 35), to the Tuffs.

Fossularca januaria n. sp.
Glycymeris lornensis Marwick
Chlamys enfieldensis n. sp.
Mantellum inconspicuum n. sp.
Limatula trulla n. sp.
Ostrea n. sp. cf. *mackayi* Suter
Eucrassatella media n. sp.
Diplodonta infrequens n. sp.
Kellia antiqua n. sp.
Nemocardium semitectum n. sp.
Venericardia benhami (Thomson)
Serpulorbis lornensis n. sp.
Siliquaria senex n. sp.
Turritella lornensis n. sp.
Turritella tophina n. sp.
Sigapatella vertex n. sp.
Uber esdailei Marwick
Trivia pinguior n. sp.
Erato vulcania n. sp.
Austrotriton n. sp.
Fusinus n. sp.
Mitra n. sp. cf. *inconspicua* Hutton
Vexillum lornense n. sp.
Semitriton revolutum (Finlay).
Clavatula humerosa n. sp.
Turricula esdailei n. sp.
Lornia limata n. sp. !

It will be seen that practically all of the species are new, and that no Recent ones are represented. The former result will not be surprising to those who have made a careful comparison of any of the earlier Tertiary faunas with Suter's lists of the same. Some of the alterations made are, of course, due to a more strict interpretation of certain species; but a glance at the revised list of locality 831 will show that in most cases the "personal factor" cannot be cited in explanation. The position must be faced that a great number of Suter's identifications are unreliable, especially those dealing with extinct species. This is all the more difficult to understand when one considers the excellence of his great book, the *Manual of the New Zealand Mollusca*, and can be ascribed only to the pressure of accumulated material causing hasty work.

The absence of Recent species in the collection indicates considerable antiquity; and, although we cannot yet tell the exact position of the Waiarekan on the European time-scale, it seems fair to conclude that it is Oligocene or late Eocene.

types of all new species described below are now in the Geological Survey collection.

Fossularca januaria n. sp. (Plate 72, figs. 1, 5.)

Shell small, oval, strong, much inflated. Beaks strong, high, at anterior two-fifths. Sculpture of sharp concentric ridges, about 7 per

millimetre, with microscopic radials in interspaces; marginal half of disc with, in addition, strong concentric growth-ridges. Hinge with about 10 anterior and 14 posterior teeth, with a considerable median space. Cardinal area somewhat short, fairly broad, with a triangular ligamental pit bearing vertical striae.

Height, 10 mm.; length, 13 mm.; thickness of one valve, 5·5 mm.

Locality 831; Esdaile collection.

Additional material has shown that the left valve differs from the right in having strong radial sculpture, also that the single ligamental groove shown in the figure of the type is only the anterior side of a shallow triangular striated pit.

Chlamys enfieldensis n. sp. (Plate 72, fig. 11.)

Shell of moderate size, inequilateral. Ears unequal. Sculpture: right valve with about 26 or 28 strong flattened radial ribs with wider interstices, finer on anterior part of disc, at about 20 mm. from apex a fine secondary rib appears in each interspace, concentric growth-lines cause scales on ribs, generally more apparent on interstitial riblet; posterior ear with 6 narrow radial ribs of different strengths; anterior with 3; left valve with about 40 rounded scaly ribs alternating in strength and appearing at successive stages in development of shell.

Height, 50 mm.; length, 50 mm.; thickness of one valve, 9 mm.

Belongs to the *C. hutchinsoni* group, but differs from that species in smaller size and fewer ribs. The only fairly complete left valve is as strongly inflated as the right, but this may be exceptional.

Mantellum inconspicuum n. sp. (Plate 72, fig. 4.)

Shell very small, thin, obliquely oval, inflated. Beaks broad, at anterior third. Ears moderate. Sculpture of about 40 sharp radials with broad rounded interstices. Hinge-margin long, one-half total length of shell. Ligament-pit broad.

Height, 4·5 mm.; length, 4·5 mm.; thickness of one valve, 1·5 mm.

Distinguished from *L. angulata* Sowb. by its small size, greater compactness, longer hinge-line, and more regular ribbing.

Limatula trulla n. sp. (Plate 72, figs. 2, 3.)

Shell small, high, well inflated, with very small ears. Sculpture on centre of disc of about 18 sharp radial ribs with wide rounded interstices; anterior and posterior areas without radials; whole surface with well-defined regular growth-lines causing denticles where they cross ribs. Hinge-area relatively broad, upper margins sloping well down, lower margin only slightly curved. Ligament-pit wide.

Height, 13 mm.; length, 7 mm.; thickness of one valve, 3 mm.

Easily distinguished from *L. bullata* Born by the smaller ears, more sloping dorsal margins, straighter sides, and small size.

Eucrassatella media n. sp. (Plate 72, fig. 6.)

Shell rather small, moderately inflated. Beaks high and strong, at anterior fourth. Anterior end narrowly rounded; posterior very broadly truncated. Lunule and escutcheon deeply sunken. Surface with regular concentric ribs separated by narrow interstices, about 16 per centimetre; sculpture developed only on centre of disc, anterior and posterior areas being smooth. Hinge of right valve with anterior cardinal very

weak, amalgamated with lunular margin for top half of length, median cardinal strong, posterior cardinal extremely weak, scarcely separated from median.

Height, 16·5 mm.; length, 20 mm.; thickness of one valve, 5·5 mm.

This species is easily distinguished from *E. trailli* (Hutton) by the strong forward-tilted beaks, sculpture confined to centre of disc, and by details of hinge.

Diplodonta infrequens n. sp. (Plate 72, fig. 9.)

Shell small, subquadrate, moderately inflated, winged posteriorly. Beaks low, at anterior fourth. Anterior end narrowly rounded; dorsal margin almost straight, slightly ascending; posterior margin straightened above, broadly rounded below. Sculpture of extremely fine regular close concentric threads, about 10 per millimetre, with a few indistinctly marked rest-periods. Left hinge with 2 cardinal teeth, anterior one thick and bifid, posterior narrow and entire.

Height, 10 mm.; length, 11 mm.; thickness of one valve, 3 mm.

Distinguished from *D. zelandica* by the much narrower anterior end and broad posterior; from the other New Zealand species by its smaller inflation.

Kellia antiqua n. sp. (Plate 72, fig. 7.)

Shell rather small, inflated, suboval. Beaks at anterior fourth. Anterior margin convex, straightened above; posterior dorsal margin almost horizontal; posterior margin straightened above, narrowly convex below; ventral margin somewhat straightened. Surface smooth with a few scattered growth-lines.

Holotype in collection of New Zealand Geological Survey.

Height, 5 mm.; length, 6·5 mm.; thickness of one valve, 1·75 mm.

The generic position is not certain, because the type and only specimen is a closed individual. One of the umbos was removed and an attempt made to explore the hinge, but without success. The shell is not a *Diplodonta*, for no ligamental nymphs can be seen. *Kellia* has an obsolete external ligament, so that the dorsal margin is not excavated; it is therefore probable that this is the correct generic location.

Nemocardium semitectum n. sp. (Plate 72, fig. 8.)

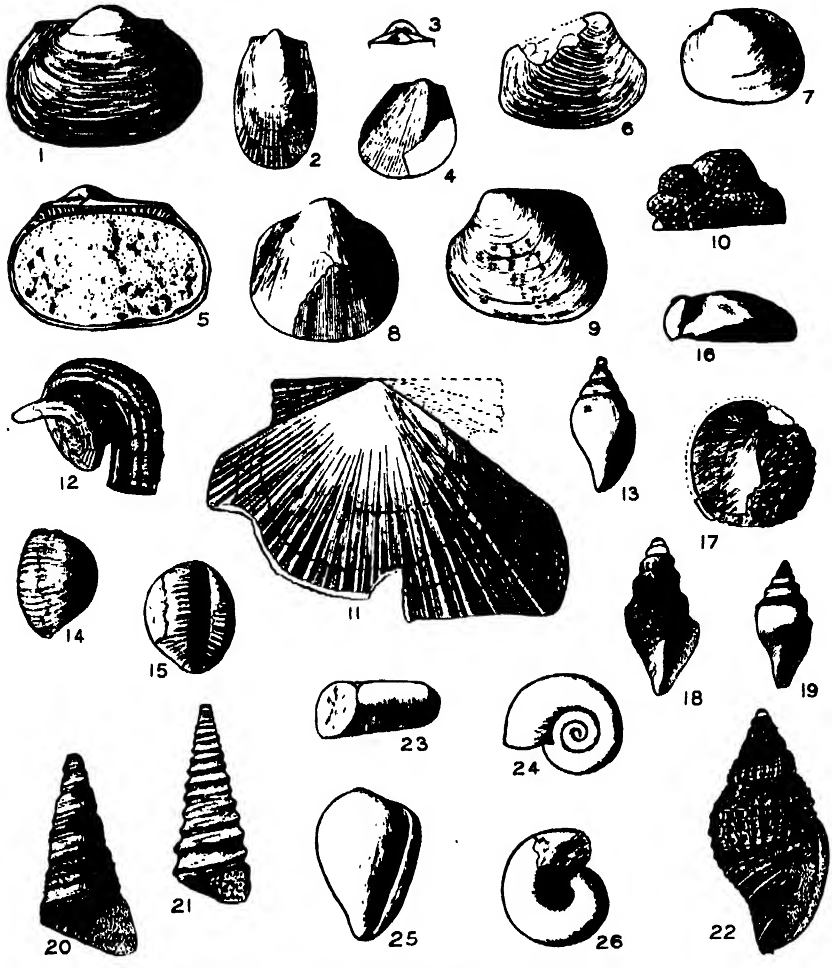
Shell rather small, subquadrate, inflated. Beaks central, prominent. Surface with 6 radial ribs per millimetre with linear interstices at 22 mm. diameter on anterior and middle of disc. Hinge weak; right valve with at least 1 conical cardinal and apparently single anterior and posterior laterals, but not well enough preserved to show clearly.

Height, 13·5 mm.; length, 13·5 mm.; thickness of one valve, 6 mm.

This is the *P. pulchella* of Suter (1921, p. 79). *N. semitecta* differs from that species in having twice as many ribs, and linear (not wide) interstices; also, the shape is more quadrate, being not so oblique posteriorly; the hinge is weaker, and the shell more inflated.

Serpulorbis lornensis n. sp. (Plate 72, fig. 10.)

Shell tubular, all that remains being closely knotted, but there was probably a projecting free tube. Sculpture of spiral cords with wider



FIGS. 1, 5.—*Fossularca januaria* n. sp. : holotype. × 2.
FIG. 2.—*Limatula trulla* n. sp. : holotype. × 1½.
FIG. 3.—*Limatula trulla* n. sp. : paratype. × 3.
FIG. 4.—*Mantellum inconspicuum* n. sp. : holotype. × 3
FIG. 6.—*Eucrassatella media* n. sp. : holotype. × 1.
FIG. 7.—*Kellia antiqua* n. sp. : holotype. × 2½.
FIG. 8.—*Nemocardium semitectum* n. sp. : holotype. × 1½.
FIG. 9.—*Diplodonta infrequens* n. sp. : holotype. × 2.
FIG. 10.—*Serpulorbis lornensis* n. sp. : holotype. × 1.
FIG. 11.—*Chlamys enfieldensis* n. sp. : holotype. × 1.
FIG. 12.—*Siliquaria senex* n. sp. : holotype. × 1½.
FIG. 13.—*Vexillum lornense* n. sp. : holotype. × 3.
FIGS. 14, 15.—*Trivia pinguior* n. sp. : holotype. × 3.
FIG. 16.—*Sigapatella vertex* n. sp. : holotype. × 2.
FIG. 17.—*Sigapatella vertex* n. sp : paratype. × 2.
FIG. 18.—*Turricula esdailei* n. sp. : holotype. × 2.
FIG. 19.—*Clavatula humerosa* n. sp. : holotype. × 1½.
FIG. 20.—*Turritella lornensis* n. sp. : holotype. × 1.
FIG. 21.—*Turritella tophina* n. sp. : holotype. × 1.
FIG. 22.—*Semitriton revolutum* (Finlay). × 1½.
FIGS. 23, 24, 26.—*Lornia limata* n. sp. : holotype. × 4
FIG. 25.—*Erato vulcania* n. sp. ; holotype. × 5.

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interstices; crossed by axials of equal strength and distance apart, nodules formed at intersections so whole surface regularly cancellate. Aperture subcircular.

Apertural diameter, 5 mm.

Siliquaria senex n. sp. (Plate 72, fig. 12.)

Shell tubular, coiled in loose irregular spiral, first whorls missing. Fissure open on last whorl, formed of a series of perforations on penultimate. Sculpture of 12 strong spaced spiral ribs with wider interstices, no ribs on inner side of whorl from fissure downwards for one-quarter of surface; each 2 mm. or 3 mm. of length marked by a transverse lamella which produces scaly spines on spiral ribs; numerous fine growth-lines in addition. Aperture subcircular.

Apertural height, 5 mm.; breadth, 4·5 mm.

Locality 831; Esdaile collection.

Turritella tophina n. sp. (Plate 72, fig. 21.)

Shell of moderate size; spire-angle about 20°. Early whorls rather flat but later ones strongly biangulate, concave between angles. Suture deep. Sculpture: earliest whorl seen (0·5 mm. diameter) has 3 spirals, top one weaker than other two, then another weak thread appears above; this arrangement holds for three whorls, then these two merge into a strong posterior angulation; meanwhile lowest spiral merges into strong anterior angulation and second lowest becomes weaker, dying out after several whorls; from then onward there are only the two strong angulations, but surface may have been lined by fine threads, as traces remain. Base with strong keel emerging from suture or just above it, another slightly weaker keel 0·5 mm. below, then fine threads. Aperture quadrate. Outer lip with a very deep narrowly rounded sinus, the apex slightly nearer posterior than anterior angulation.

Height, 28 mm.; diameter, 9 mm. (incomplete).

The neanic stage is the same as the adult *T. waihaoensis* Marwick, so *T. tophina* must be a later development of that species. One specimen, an adult body-whorl, has a weak median thread persisting, but it differs from *T. waihaoensis* in that the whorl is strongly concave as in *T. tophina*, and the posterior angulation does not have the double thread shown by *T. waihaoensis*. The specimen then is probably better considered as a *T. tophina* in which the sculpture has developed more slowly than usual.

Turritella lornensis n. sp. (Plate 72, fig. 20.)

Shell of moderate size; spire-angle about 20°. Early whorls convex, later flat to slightly concave. Suture shallow. Sculpture: earliest whorl seen (1·5 mm. diameter) has 4 principal spiral threads, anterior two being slightly stronger; broad flat interspaces with a very weak moniliform thread, 2 on posterior space, later there are 3 secondaries on anterior space, middle one strongest; in some specimens adult whorls have primaries and secondaries almost equal in strength, the latter having about doubled their number;. generally, however, there are 2 stronger spirals on the anterior swelling of whorl and from 2 to 4 on posterior; growth-lines prominent. Base sharply keeled and spiralled by well-spaced threads. Aperture quadrate. Outer lip deeply and widely sinused, the apex slightly above the middle of the whorl.

Height, 14·5 mm.; diameter, 6 mm. (incomplete).

This species is related to *T. carlottae*, but is much smaller, has weaker and more spaced primary spirals, also the surface is not crowded with fine threads.

Sigapatella vertex n. sp. (Plate 72, figs. 16, 17.)

Shell small, rounded, convex. Spire lateral, projecting. Whorls 3 including protoconch. Sculpture of dense microscopic waved spiral riblets. Basal plate twisted, with smooth sigmoid margin. Umbilicus well marked, round in cross-section, not penetrating past body-whorl; set well back from the margin of basal plate.

Height, 5 mm.; diameter, 9 mm.

Trivia pinguior n. sp. (Plate 72, figs. 14, 15.)

Shell small, broadly oval, slightly narrowing anteriorly. Sculpture of about 22 narrow strong rounded transverse ribs, with interstices slightly wider; ribs extend upwards from aperture over dorsal surface, but the only specimen does not show to what extent they were interrupted along median line.

Height, 7·5 mm; diameter, 6 mm.

Distinguished from *T. zealandica* by its much greater obesity.

Mitra n. sp.

Fragments of a *Mitra* closely allied to *inconspicua*, but with much more convex whorls. Too imperfect for identification.

Vexillum lornense n. sp. (Plate 72, fig. 13.)

Shell small, fusiform, spire slightly less than aperture. Whorls 5 besides protoconch, slightly convex; body-whorl comparatively large, gradually contracted at base. Protoconch paucispiral, globular with tilted apex. Sculpture obsolete, surface obscurely and finely trellised. Aperture narrow, sides subparallel, angled posteriorly, not notched anteriorly. Outer lip thin, convex, antecurrent to suture, retreating to anterior end of columella, but not contracted to a canal. Columella with 3 oblique median folds.

Height, 6·5 mm.; diameter, 3 mm.

This shell is not by any means a typical *Vexillum*, and may be nearer *Conomitra*. Probably a new generic division is required, but the matter can stand over until more material is available.

Erato vulcania n. sp. (Plate 72, fig. 25.)

Shell small, inflated, oval, spire very low. Body whorl convex, obese. Protoconch concealed by enamel. No sculpture. Aperture long, narrow, with subparallel sides, truncated, not notched anteriorly, curved towards apex at top. Outer lip convex, thickened, practically smooth within, ascending to top of penultimate whorl. Columella smooth above, with 2 or 3 rudimentary folds close together at anterior end, traversed by a shallow longitudinal groove.

Height, 4 mm.; diameter, 3 mm.

The columellar folds are so poorly developed that they are seen only on a close inspection of well-preserved specimens. A lens reveals on the inner surface of outer lip a few irregularities which may be rudimentary denticles.

Semitriton revolutum (Finlay). (Plate 72, fig. 22.)

1924. *Cymatium revolutum* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 456, pl. 51, figs. 2*a*, 2*b*.

Shell of moderate size, fusiform. Spire about equal to aperture and canal. Whorls 5 besides protoconch, convex; body-whorl relatively large, regularly convex contracting gradually to almost straight neck. Protoconch tectiform, of 3 whorls with small nucleus. Sculpture: first, 3 spirals appear and soon after 2 weaker ones posterior to the others; on later whorls 5 spirals approximately of equal strength; interstices equal to spirals anteriorly, narrower posteriorly; axial ornamentation of 20–24 narrow ribs extending across spire-whorls and forming nodules where they intersect spirals, so that surface is divided into a large number of equal squares; fine spiral threads occupy interspaces, about 3 in each, these also regularly trellised by fine growth-lines; body-whorl has 19 primary spirals, interspaces of those below line of suture with one secondary stronger than the others, 4 more close spiral threads anterior to these on neck. Obsolete varices at about each two-thirds of a whorl. Suture well marked. Aperture subrhomboidal, produced into an almost straight wide canal not notched anteriorly. Outer lip straight, thickened, dentate within. Columella straight with 2 strong oblique folds. Inner lip not calloused, so that spiral sculpture enters aperture; 2 or 3 irregular denticles anterior to columellar folds.

Height, 23 mm.; diameter, 11 mm.

This genus is an Australian one founded on *Plesiotriton dennanti* Tate from Cape Otway. Cossmann in founding the genus (1903, p. 102) describes the protoconch as "globuleuse, paucispirée, à nucleus assez gros et dévié," but this does not agree with our specimen. Since the agreement of the shells is so close in other matters, it may be that some mistake due to imperfect preservation has been made.

Ficus transennus Suter belongs to this genus; indeed, as the type is an internal cast it is scarcely possible to be certain about the specific difference of *S. revolutum*. The former is considerably larger, and until more material is obtained it is safer to keep the two species apart.

The manuscript of the present contribution was written before the publication of Mr. Finlay's paper; in it this shell had been described as new, and the writer is indebted to Mr. Finlay for pointing out the agreement with his species. As the Waiarekan shell is better preserved than the types, the description and figure have not been deleted.

Clavatula humerosa n. sp. (Plate 72, fig. 19.)

Shell rather small, fusiform. Spire equal to aperture and canal. Whorls 5 below protoconch, with short sloping shoulder below which they are almost cylindrical; body-whorl with rapidly contracted base and fairly long lightly twisted neck. Protoconch conoidal of about 4 smooth whorls. First succeeding whorl with about 12 axial ribs raised into strong nodules on shoulder, on next whorl ribs decline into nodules which disappear after another turn, base of body-whorl with numerous fine close spiral threads. Aperture narrowly ovate, produced into moderately long wide canal which is not notched at end. Contour of outer lip uncertain. Columella straight. Smooth thin inner lip extending down along narrow inner margin of canal.

Height, 11·5 mm.; diameter, 5 mm.

Until the outer lip is known the generic position will be uncertain. The two species which Suter classed under this genus, *C. neozelanica* and *C. mackayi*, are not likely to be confused with the new one. The former has a deep anterior notch and fasciole and is an *Austrotoma;* the latter has flat whorls with a bordered suture and a lightly sinuous outer lip.

Turricula esdailei n. sp. (Plate 72, fig. 18.)

Shell small, fusiform. Spire equal to aperture and canal. Whorls 4 besides protoconch, with high concave shoulder, straight below; body-whorl fairly quickly contracting to moderately long slightly-twisted neck. Protoconch tectiform, of 5 whorls, nucleus minute, last half-whorl with 6 faint spirals crossed by weak axials. Sculpture of 15 strong axial ribs barely showing on shoulder and becoming weak on base, interstices of equal width; spiral cords 4 or 5 on spire-whorls, about 15 on body-whorl have wide interstices with a fine threadlet, shoulder with about 8 fine close spirals, spirals are trellised and rendered moniliform by numerous raised growth-lines. Aperture ovate, channelled above, produced below into a fairly wide canal not notched at base. Outer lip thin, with an arcuate sinus on shoulder, then sweeping forward in middle and base of body-whorl. Columella straight. Inner lip thin.

Height, 15 mm.; diameter, 7 mm.

The generic location is only provisional. The ornamentation and outer lip are similar to those of *Austrotoma*, but there is no anterior notch to the canal.

Lornia n. gen. Type, *Lornia limata* Marwick.

Lornia limata n. sp. (Plate 72, figs. 23, 24, 26.)

Shell small, thin, sinistral, planorbid. Whorls rather plump; body-whorl inflated, expanding round aperture; apical whorls sometimes slightly sunken. No sculpture. Aperture oval, entire. Umbilicus large, but not excessively so.

Height, 2 mm.; diameter, 4 mm.

The relationship of this shell is rather puzzling. Another species occurs in the Paleocene of Wangaloa.

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New Tertiary Mollusca from North Taranaki.

By J. MARWICK, M.A., D.Sc., New Zealand Geological Survey.

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Plates 73–75.

THE shells described below were collected in north Taranaki by Mr. L. I. Grange during the course of his geological survey of that district. The sediments examined probably belong to the Upper Miocene, and are intermediate between the Awamoan and the Waitotaran, though they no means bridge the gap. The present paper is purely systematic; the stratigraphical and palaeontological results will be discussed later by Mr. Grange. The type specimens are in the collection of the New Zealand Geological Survey.

Melanopsis waitaraensis n. sp. (Plate 73, figs. 1, 2.)

Shell large, narrowly fusiform. Spire acute, higher than aperture. Spire-whorls lightly convex, body-whorl not greatly expanded, subcylindrical, with rounded sloping shoulder. Suture strongly impressed, bordered below. Sculpture: spire-whorls with about 30, body-whorl with 40 strong rounded ribs with narrower interstices, ribs persist from suture to suture but not across base of body, they curve strongly forward below so that a wide sinus is formed; waved spiral incised lines are seen on lower parts of some whorls and on body-whorl stronger on base, spiral depression on ribs forms border just below suture. Aperture imperfect but like *Melanopsis*. Columella bent forward and inwards, bearing two extremely weak, oblique folds, not always seen.

Height, 75 mm.; diameter, 25 mm. (both estimated).

Localities.—1141, coast south side Wai-iti Stream (type); 1133, coast north of Mimi Stream.

This shell is congeneric with *Coptochetus zelandicus* Marshall from Pakaurangi, but has many more ribs. The aperture, so far as seen, is exactly the same as that of *Melanopsis pomahaka* Hutton; therefore the generic position is far removed from *Coptochetus*, which has a smooth convex twisted columella.

Cerithidea tirangiensis n. sp. (Plate 73, fig. 3.)

Shell small, with acute spire four times height of aperture. Whorls flattened, body with almost flat base and short neck. Suture deep, bordered above. Sculpture: early whorls with 10, later with 11 strong rather narrowly rounded axial ribs with much wider interstices, reaching to periphery of body-whorl, crossed on spire-whorls by four strong well-spaced spiral threads forming slightly nodulous intersections, basal periphery strongly bicarinate, upper spiral issuing from suture having formed border, axials reach it but do not pass or render nodulous, lower spiral separated by more than its own width, rest of base smooth. Columella slightly arcuate, smooth.

Height, 12·5 mm.; diameter, 4·8 mm.

Locality.—1135, Tirangi Stream.

Easily distinguished from *C. bicarinata* (Gray) by small size, straighter ribs, and 4 spirals on spire-whorls; also from *C. subcarinata* Sowerby by the 4 spirals and absence of additional spiral on base.

Struthiolaria praenuntia n. sp. (Plate 73, fig. 7.)

Shell large. Spire high, turreted. Whorls bicarinate, with broad sloping shoulder. Body-whorl concave between shoulder and keel, base quickly contracted. Sculpture: spire-whorls with 2 broad cingula, upper at shoulder, lower midway to anterior suture; body-whorl strongly keeled, middle cingulum becoming weaker and finally disappearing; whole surface with sharp, spaced spiral threads. Suture bordered by narrow *rampe* or flattening of whorl. Aperture round. Outer lip thickened and reflexed, bisinuate. Columella concave. Inner lip thin.

Height, 52 mm.; diameter, 32 mm.

Locality.—1135, Tirangi Stream.

The persistence of the second cingulum on spire-whorls and even on to body-whorl is a distinctive feature for a shell of the *papulosa* group. In a previous paper the writer (*Trans. N.Z. Inst.*, vol. 55, p. 167) treated this character as catagenetic, and consequently placed the divergence of the *vermis* group from the *papulosa* group well back in the Tertiary. *S. praenuntia*, however, shows that the second cingulum was anagenetic during the Miocene, reaching its maximum for the *papulosa* group in this species. The small *S. nana* described below from the same beds is much like a miniature *S. praenuntia*, but is almost certainly an ancestor of *S. vermis*.

Struthiolaria nana n. sp. (Plate 73, fig. 4.)

Shell small. Spire turreted, about as high as aperture; early whorls convex, later ones biangulate with broad slightly rounded sloping shoulder; body-whorl bicarinate with concave shoulder and sides, base quickly contracted. Sculpture: about third whorl 2 cinguli appear, upper on shoulder-angle bearing weak tubercles for a short distance, lower in middle of side, these persist until body-whorl when lower one gets much weaker; another cingulum marks the strong keel of the body-whorl, and base has 5 or 6 very weak ones; whole surface with fine distant spiral threads and microscopic lirae. Suture bordered below by a flattening of whorl. Aperture oval, with a shallow anterior sinus. Outer lip thickened, reflexed, lightly bisinuous. Columella concave, beak curved inwards and forward. Inner lip calloused, definitely limited, thinner and but slightly spread on parietal wall.

Height, 28 mm.; diameter, 17·5 mm.

Locality.—1135, Tirangi Stream.

The recent *S. tricarinata* Lesson is closely similar, but *S. nana* can be distinguished by the very fine spiral threads of regular strength over the whole surface. Also the flat border, or *rampe*, below the suture is much narrower than in the Recent species, and the shell is considerably smaller.

Crepidula haliotoidea n. sp. (Plate 73, fig. 10.)

Shell of moderate size, oval, strong. Apex raised, coiled inwards and upwards from margin for almost half a whorl, with greatest growth longitudinally. Surface with strong irregular growth ridges, no radial sculpture. Aperture oval, oblique; outer margin thin; inner margin thick, flattened.

Height, 24 mm.; longitudinal diameter, 37 mm.; maximum breadth, 25 mm.

Locality.—1135, Tirangi Stream.

The external form of this shell is very like that of *Haliotis virginea* Gmelin, but the apex has not so many whorls and the row of perforations is absent. The basal plate cannot be seen because of the hard matrix in the aperture; but a longitudinal section of it was disclosed on breaking off the side of the shell. The sides of the plate extended about two-thirds the length of the body; but the anterior margin was slightly concave, in the young stage at least, as shown in the broken apex.

Lippistes pehuensis n. sp. (Plate 73, figs. 6, 8.)

Shell large, subdiscoidal, inflated, test thin. Spire scarcely projecting, surpassed but not involved by body. Whorls convex; body-whorl increasing rapidly in size, with narrow umbilicus. Suture impressed. Sculpture of about 13 broad very low spirals, absent on umbilical area, and becoming obsolete round aperture, crossed by numerous waved fairly strong growth-ridges. Aperture subcircular, dilated, adhering to parietal wall, with a well-marked sinus well out on lower margin; on early part of body this sinus forms low ridge bounding umbilicus.

Greatest height (= aperture), 29 mm.; total diameter, 34 mm.; diameter of aperture, 29 mm.

Locality.—Okoke Road, 60 chains west of Pehu Trig., Upper Waitara Survey District.

Phalium grangei n. sp. (Plate 73, fig. 17.)

Shell of moderate size, suboval, inflated. Spire low, gradate to subconic, under one-third height of aperture. Spire-whorls obtusely angled, with a broad almost flat shoulder; body-whorl with slightly concave shoulder below which it is inflated, base contracting quickly to short twisted neck bearing a conspicuous fasciole separated from constricted base by strong ridge. Sculpture: early whorls eroded, penultimate whorl with about 5 spiral threads on side and 6 on shoulder; interstices wide, each containing a secondary spiral; shoulder-angle with about 20 low blunt knobs; body-whorl with 8 cinguli, top one strongest, bottom five scarcely marked, top three with 12 to 16 rounded knobs, fourth sometimes with a few obscure ones, whole whorl with fine spiral threads. Suture strongly impressed, bordered on body by flattened cord crossed by strong oblique growth-lines. Aperture very deeply and obliquely notched below. Outer lip thickened, much reflexed. Columella somewhat damaged in all specimens but apparently with one strong grooved oblique fold at bottom of columella, above which are a number of wrinkles. Inner lip thin on the parietal wall, thickened below, fitting close to base and fasciole so that ridges of latter show through, and there is no umbilicus.

Height, 43 mm.; diameter, 32 mm.

Locality.—1135, Tirangi Stream.

Easily distinguished from other New Zealand species of *Phalium* by the rows of low, rounded knobs, also by the close-fitting inner lip. Many of the shells called by Suter *Galeodea senex* belong to this group, also *Galeodea muricata* (Hector). The strong sculpture was used as the basis of a subgenus, *Echinophoria* Sacco, but Cossmann does not think the group worth recognition. The shell described above is far removed from *Phalium* s. str., and should be generically separated. The whole family, however, needs revision.

Cirsotrema angulata n. sp. (Plate 73, fig. 5.)

Shell small, imperforate, turreted. Spire-whorls bluntly angled slightly below middle; body-whorl with a second keel extending from suture, base flat, with a prominent fasciole. Sculpture of 13 strong spaced rough axial ribs per whorl, interstices with a strong spiral thread following periphery and another weaker one on side of spire-whorls, on body-whorl it is intermediate between periphery and keel, in addition many fine close spiral threads in interstices; base with strong radials formed by continuation of axials. Aperture circular, effuse to left below to form large fasciole.

Height, 9 mm.; diameter, 4 mm.

Locality.—1133, Mimi Stream.

Easily distinguished by angled spire-whorls.

Euthriofusus tangituensis n. sp. (Plate 73, fig. 9.)

Shell of moderate size, fusiform. Spire turreted, acute. Whorls, 6 remaining, bluntly angled below the middle with a sloping slightly concave shoulder; body-whorl strongly shouldered, contracted quickly on base to long neck. Sculpture: first two whorls with 12 to 13 axial ribs on sides, not crossing shoulder, these axials soon become obsolete, and are absent on third whorl, appearing again on fourth and persisting till aperture is reached, about 14 on body-whorl where they do not cross base, spiral sculpture of fine threads, 3 fairly prominent on first whorl, second whorl has 1 on angle, 1 on shoulder, and 1 on side with weaker one in each interspace, and 3 or 4 posterior ones on shoulder, on third whorl spirals are almost equal in strength, on fourth and fifth there are 3 prominent threads on rounded periphery, separated by 1–3 fine threads, above and below are equally fine spaced spiral threads; body-whorl with about 13 principal spirals, highest just above periphery, lowest about junction with neck, which bears about 11 weaker threads, interspaces of those on body generally with 3, in one case 5, very fine spaced threads; growth-lines very fine and regular. Aperture oval, produced below into very long straight canal, inclined slightly to left. Outer lip thin, retracted from suture in wide sweeping sinus. Columella with strong fold at junction of canal. Inner lip thin.

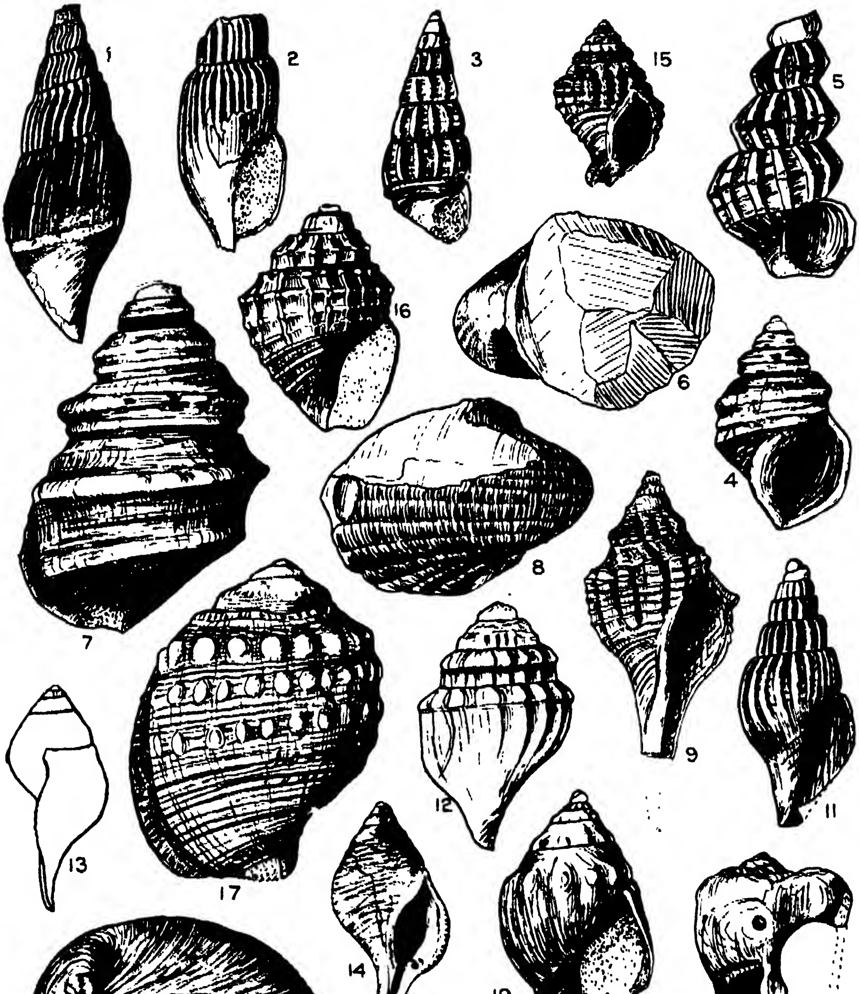
Height (estimated), 50 mm.; diameter, 20 mm.

Locality.—1142, 30 chains south-south-west junction of Tangitu Stream and Waitara River.

This species is not connected with *Euthriofusus spinosus* Suter, which is a Turrid related to *Surcula occidentalis* Woods from the Eocene of north-west Peru.

Vexillum ambulacrum n. sp. (Plate 73, fig. 11.)

Shell small, fusiform. Spire turreted, equal to aperture and canal in height. Protoconch paucispiral. Whorls flattened, body-whorl straight above but curving strongly below to short neck. Suture bordered below by narrow flat *rampe*. Sculpture: 17 to 19 strong smooth axial ribs with equal or narrower interstices, persisting on spire-whorls but dying out on base of body, also becoming obsolete on nearing aperture; 6 to 8 low flat spiral cords with narrow to linear interstices on sides of whorls and two on *rampe*, spirals do not surmount ribs, being well marked only in interstices; body-whorl with about 25 spirals which are scarcely perceptible on the convexity, but a few on neck are plainly seen. Aperture



Figs. 1, 2.—*Melanopsis waitaraensis* n. sp.: holotype and paratype. × 1.
Fig. 3.—*Cerithidea tirangiensis* n. sp.: holotype. × 2½.
Fig. 4.—*Struthiolaria nana* n. sp.: holotype. × 1.
Fig. 5.—*Cirsotrema angulata* n. sp.; holotype. × 5.
Figs. 6, 8.—*Lippistes pehuensis* n. sp.: holotype. × 1.
Fig. 7.—*Struthiolaria praenuntia* n. sp.: holotype. × 1.
Fig. 9.—*Euthriofusus tangituensis* n. sp.: holotype. × 1.
Fig. 10.—*Crepidula haliotoidea* n. sp.: holotype. × 1.
Fig. 11.—*Vexillum ambulacrum* n. sp.: holotype. × 4.
Fig. 12.—*Vexillum fractum* n. sp.: holotype. × 6.
Figs. 13, 14.—*Streptopelma henchmani* n. sp.: holotype. × 1.
Fig. 15.—*Aethocola cliftonensis* n. sp.: holotype. × 1.
Fig. 16.—*Admete cristata* n. sp.: holotype. × 8.
Fig. 17.—*Phalium grangei* n. sp.: holotype. × 1.
Fig. 18.—*Cominella hendersoni* n. sp.: holotype. × 1.
Fig. 19.—*Cominella compacta* n. sp.: holotype. × 1.

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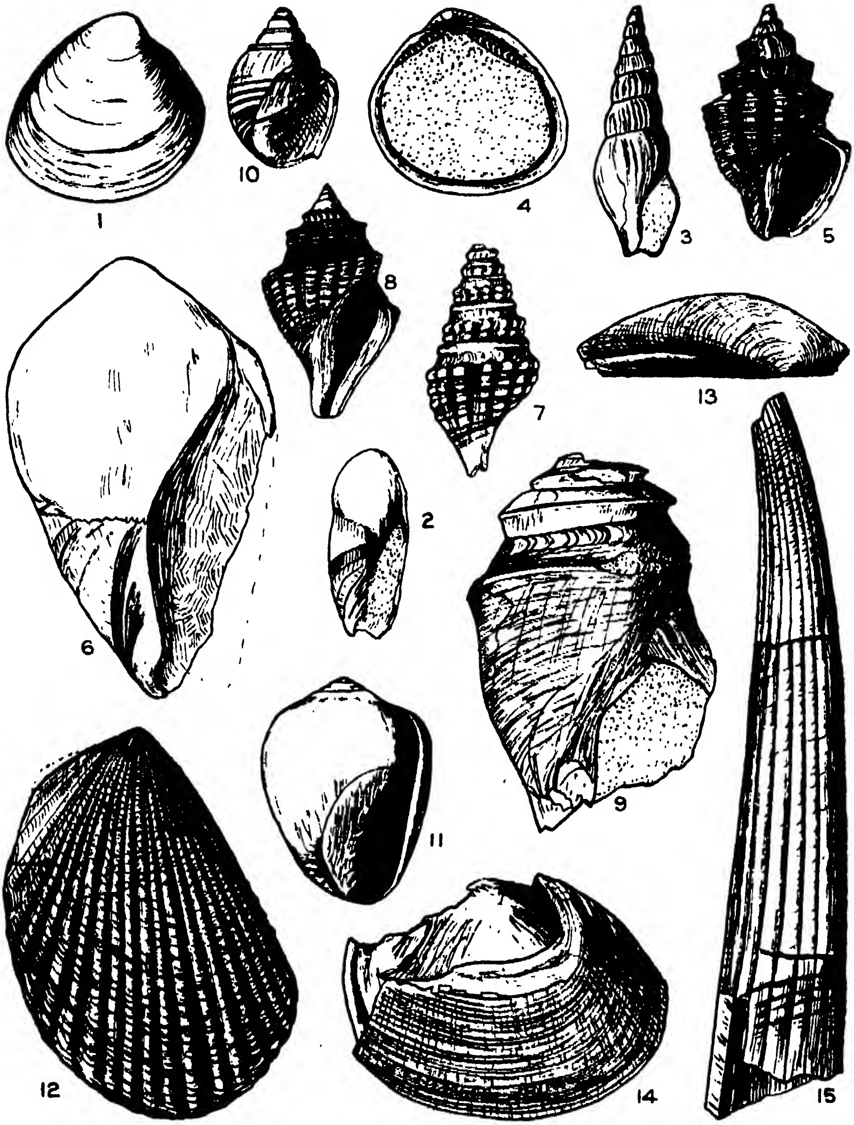
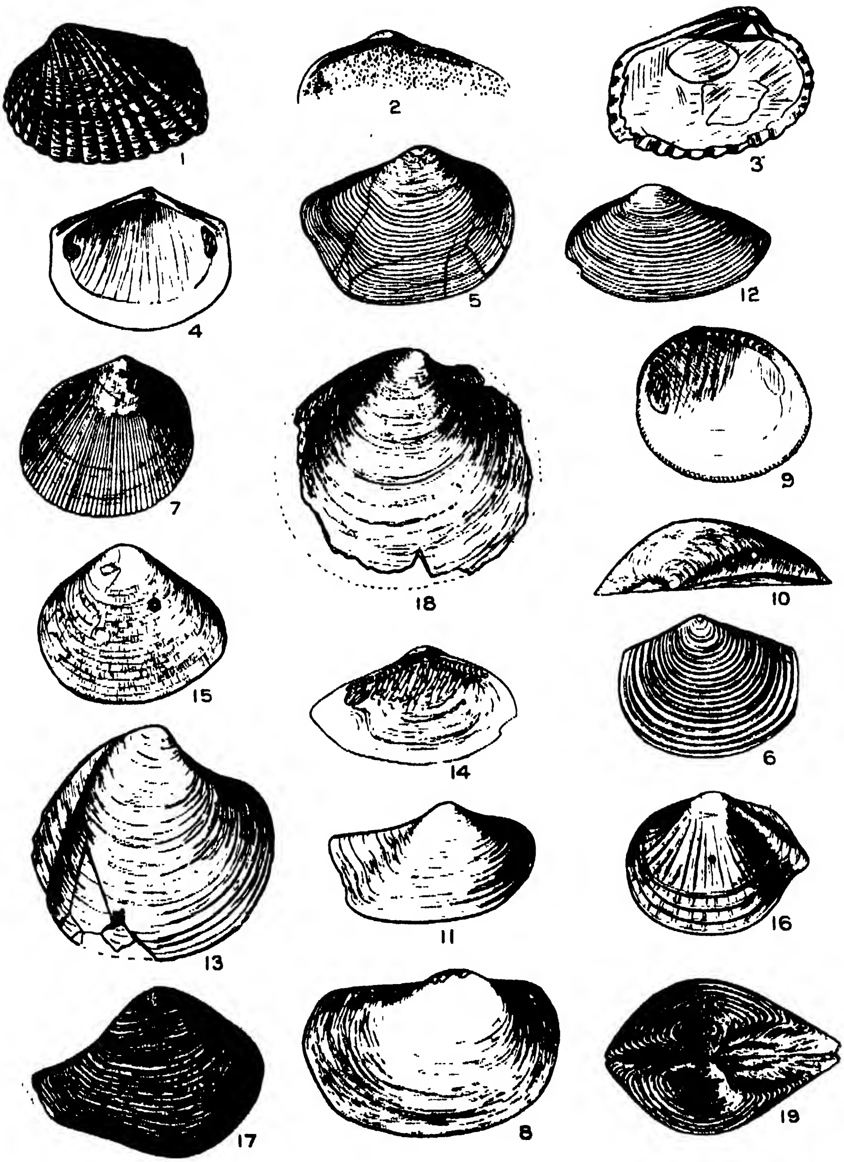


Figs. 1, 4.—*Nucula grangei* n. sp. : holotype. × 4.
Fig. 2.—*Ancilla subhebera* n. sp. : holotype. × 1.
Fig. 3.—*Terebra omahuensis* n. sp. : holotype. × 1.
Fig. 5.—*Mangilia taranakiensis* n. sp. : holotype. × 5.
Fig. 6.—*Ancilla tirangiensis* n. sp. : holotype. × 1.
Fig. 7.—*Inquisitor asper* n. sp. : holotype. × 2½.
Fig. 8.—*Turricula curtata* n. sp. : holotype. × 1½.
Fig. 9.—*Turricula waitaraensis* n. sp. : holotype. × 1.
Fig. 10.—*Ringicula torquata* n. sp. : holotype. × 5.
Fig. 11.—*Marginella whitecliffensis* n. sp. : holotype. × 5.
Fig. 12.—*Lima watersi* n. sp. : holotype. × 1.
Figs. 13, 14.—*Nucula otamaringaensis* n. sp. : paratype and holotype. × 1½.
Fig. 15.—*Dentalium otamaringaensis* n. sp. × 1.



FIGS. 1, 3.—*Venericardia urutiensis* n. sp.: holotype. × 1.
FIGS. 2, 5.—*Neilo waitaraensis* n. sp.: holotype. × 4.
FIGS. 4, 6.—*Myrtaea (Eulopia) papatikiensis* n. sp.: holotype. × 4.
FIGS. 7, 9.—*Nucula ruatakiensis* n. sp.: holotype. × 4.
FIG. 8.—*Malletia (Minormalletia) tenera* n. sp.: holotype. × 5.
FIGS. 10, 13.—*Thyasira planata* n. sp.: holotype. × 3.
FIG. 11.—*Neilo sublaevis* n. sp.: holotype. × 1.
FIGS. 12, 14.—*Nuculana ellisi* n. sp.: holotype. × 2.
FIG. 15.—*Leptomya simplex* n. sp.: holotype. × 5.
FIG. 16.—*Zealeda mutabilis* n. sp.: holotype. × 10.
FIGS. 17, 19.—*Nuculana onairoensis* n. sp.: holotype. × 3.
FIG. 18.—*Lucinida tirangiensis* n. sp.: holotype. × 1.

elongate, oval, produced below into short fairly wide canal not notched anteriorly. Outer lip thin, straight. Columella straight, with 4 oblique folds decreasing in strength anteriorly. Inner lip thin.

Height, 9 mm., diameter, 4·5 mm.

Locality.—1135, Tirangi Stream.

Vexillum fractum n. sp. (Plate 73, fig. 12.)

Shell small, broadly fusiform. Spire turreted, about equal in height to aperture. Whorls strongly angled, with high narrow shoulder and vertical sides; body-whorl similar above, rounded off on base and contracting quickly to short neck. Sculpture: about 16 weak axial ribs, which are gathered into strong beads on shoulder-angle and become obsolete on base; strong moniliform spiral follows shoulder-angle, otherwise spirals are obsolete. Aperture long and narrow, not notched below. Columella with 4 oblique folds.

Height, 6 mm.; diameter, 3 mm.

Locality.—1133, Mimi Stream.

Streptopelma henchmani n. sp. (Plate 73, figs. 13, 14.)

Shell rather small, fusiform. Spire conical, about half height of aperture and canal. Whorls five, almost flat on spire, sometimes slightly concave and sometimes slightly convex; body-whorl plump, contracting rapidly to fairly long and slender neck, which is slightly recurved, has sharp edges and no fasciole. Suture impressed. Sculpture: numerous spiral threads separated by interspaces of about twice the width, about 8 spirals on the penultimate whorl and about 22 on body, probably more on neck, which is weathered in type specimen; first three whorls have each from 18 to 20 short axials which become obsolete. Aperture ovate, channelled above, and produced below into moderate canal which is bent slightly to left and backwards and not notched. Outer lip crenate with sharp edge, thickened within, and with 2 denticles near canal; viewed laterally lip has broad sinus above and is then prominently lobed, inner lip with thin callus, which has a number of small tubercles (not always present) towards base. Columella short and straight with weak fold at its junction with canal.

Height, 30 mm.; diameter, 16 mm.

Localities: 1134 (type), coast 20 chains north of shelly conglomerate a little north of mouth of Papatiki Stream, Waitara Survey District; 1133, coast from Mimi Stream north for one mile, Waitara Survey District; Huiroa bore (between 4,550 ft. and 4,760 ft.), ten miles north-east of Stratford.

The genus *Streptopelma* Cossmann (1901) is based on an Australian Tertiary shell, *Peristernia lintea* Tate, which much resembles the New Zealand species, being more slender, with a higher spire and with the outer lip having the crenulations set farther back from the edge. Another New Zealand species is *Siphonalia orbita* Hutton, a larger shell with very strong spirals.

Aethocola cliftonensis n. sp. (Plate 73, fig. 15.)

Shell rather small, broadly fusiform. Spire gradate, about two-thirds height of aperture and canal. Whorls 5, strongly shouldered and rising on to preceding whorl; body-whorl rapidly contracting to short strongly

twisted neck which has well-marked fasciole bounded above by projecting ridge. Suture undulating, impressed, deeply bordered below. Sculpture: from 15 to 17 strong axial ribs which are weaker on shoulder and die out on base of body-whorl, these are crossed by strong spirals with wide interspaces; the concave shoulder bears from 5 to 7 close spiral threads and on spire-whorls about 4 strong threads below these; body-whorl with about 11 strong spirals. Aperture ovate, channelled above, produced below into short wide strongly twisted canal, deeply notched at base. Outer lip thin, straight. Inner lip lightly calloused. Columella straight, smooth.

Height, 22 mm.; diameter, 15 mm.

Localities.—1116 (type), coast 10 chains north of Mangapuketea Stream, Mimi Survey District (L. I. Grange); 1144, Okoke Road, 60 chains west of Pehu Trig, Upper Waitara Survey District; 1136, Mangare Road deviation to head of Mangaone Stream, 5 chains west of tunnel, Upper Waitara Survey District; Huiroa bore (between 4,550 ft. and 4,760 ft.), ten miles north-east of Stratford.

This shell is perhaps nearest to *Aethocola robinsoni* (Zittel) and *Aethocola zitteli* (Suter). Good specimens of these species from the type locality, Nelson, have not been seen, but the material available justifies the separation of *A. cliftonensis.* The shape is different from either because of the concave shoulder and the deeply bordered suture.

Cominella compacta n. sp. (Plate 73, fig. 19.)

Shell of moderate size, broadly fusiform, strong. Spire about two-thirds height of aperture. Protoconch tectiform, of 2 smooth whorls with large nucleus. Post-embryonic whorls 4½, early ones convex, later with long sloping concave shoulder below which they are convex; body-whorl fairly quickly contracted below shoulder-angle to prominent raised fasciole which is bounded above by sharp ridge. Suture slightly undulating. Sculpture: 11 to 12 rounded knobs on blunt shoulder-angle, on first post-embryonic whorl represented by axials reaching from suture to suture; there are obsolete spiral cords, but so weak that they cannot be numbered. Aperture ovate, channelled above, produced below into short widely-open canal which obliquely truncates columella and is deeply and widely notched anteriorly. Outer lip thin, lightly sinuous, smooth. Columella arcuate, smooth. Inner lip thin, extending down along edge of canal.

Height, 31 mm.; diameter, 20 mm.

Locality.—Tirangi Stream.

The type has been squeezed somewhat out of shape and so appears wider than it was originally.

Cominella hendersoni n. sp. (Plate 73, fig. 18.)

Shell moderate size, broadly cylindrical. Spire conic, low. Protoconch small. First post-embryonic whorls regularly convex, later ones with flattened sides, and high shoulder embracing the previous whorls; body-whorl subcylindrical, shoulder irregularly curved over to suture, contracted quickly below to huge prominent fasciole, which is sometimes deeply umbilicated, sometimes not at all. Sculpture: early whorls with from 10 to 12 rounded axial ribs and numerous spiral threads; axials soon disappear and afterwards growth of whorls is so irregular that spirals are obscured. Suture irregular, on body-whorl filled with broad callus which occupies most of shoulder. Aperture oval, anterior produced into short

obliquely twisted canal, deeply notched at extremity; posterior filled with thick callus, on outer side of which is shallow groove. Outer lip broken in all specimens but apparently thin and convex, separated from penultimate whorl by wide sutural callus. Columella concave, obliquely truncated below, where it bounds the short curved canal. Inner lip rather thick, definitely bounded in fasciolar region.

Height, 24 mm; diameter, 21 mm. (small specimen).

Locality.—1135, Tirangi Stream.

A highly gerontic development of the *Cominella maculata* type. There is considerable variation in the amount of gerontism displayed; some specimens show little embracing and are oval in shape, in others the body-whorl almost conceals the spire and the shape is subcylindrical. Distinguished from *C. ridicula* Finlay by much greater breadth, thicker callus, and less flattened sides.

" Admete " cristata n. sp. (Plate 73, fig. 16.)

Shell very small, ovate. Spire turreted, equal to aperture in height. Protoconch of about 4 smooth tectiform whorls, nucleus extremely small, first two whorls almost planorbid. Post-embryonic whorls nearly 3, biangulate on spire; body with convex contracting base not produced into neck. Sculpture of 14-16 sharp narrow well-spaced axial ribs, mostly becoming obsolete on base but one or two persist, strong moniliform spiral cord just below suture, forming upper angle, weaker thread on lower angle and another on side of spire-whorls, 4 additional ones on base. Aperture angled above, not notched below. Outer lip thin, straight, strongly retracted from suture. Columella short with strong twist but no plaits.

Height, 4 mm.; diameter, 2·5 mm.

Locality.—1125, coast between Waikiekie and Mangapuketea Streams.

This shell is not an *Admete*, as shown by the protoconch and the absence of columellar plaits. A new generic division appears to be required for its reception; but, as the single specimen may not be an adult, it is advisable to wait for more specimens.

Ancilla (Baryspira) subhebera n. sp. (Plate 74, fig. 2.)

Shell small, cylindrical. Spire about two-thirds height of aperture, buried in thick blunt callus which descends well on to body-whorl. Sides of body slightly convex; spine-bearing groove at bottom of smooth area well separated from calloused basal limb, leaving relatively wide depression. Basal limb with a narrow but well-marked median groove, separated by another deep groove from beak. Aperture long and narrow, tapering gradually above, deeply notched below. Outer lip retracted above to join apical callus, with short spike opposite spiral groove. Columella slightly concave, widening below rather quickly to form obliquely truncated beak with 1 strong groove above and 3 weak ones below. Inner lip narrow along most of its length, but callus extends upwards and then spreads out slightly below line of apical callus, reaching almost 180° from outer lip and up to apex, and forming rather thick rounded pad.

Height, 25 mm.; diameter, 10 mm.

Locality.—1135, Tirangi Stream.

Differs from *A. hebera* (Hutton) in the great development of the apertural callus, also in its larger size. The spread of this callus resembles that of *A. tatei* Marwick from the lower beds, Muddy Creek, but is carried still farther.

Ancilla (Baryspira) tirangiensis n. sp. (Plate 74, fig. 6.)

Shell large, heavy, subcylindrical. Spire up to one-third height of aperture, low-conical to dome-shaped. Spire-whorls covered with heavy callus which descends over angle of shoulder of body-whorl. Smooth band relatively narrow, bounded below by wide depressed band, the raised ridge between this and fasciole of anterior notch is also wide, and is bounded below by well-marked broad shallow sulcus. Aperture inclined, hastate, deeply and broadly notched below, channelled above, channel extending a considerable distance across spire-callus. Outer lip retreating above, with short spike at bottom of smooth area. Columella short, concave, twisted strongly forward below and expanding into broad beak which has single broad longitudinal sulcus bounded on outside by narrow ridge, this in turn is separated from basal limb by broad rather deep groove. Inner lip spreading as thick callus-pad on parietal wall, and extending across smooth area reaches back of shell and almost up to spire, its outline circular.

Height, 59 mm.; diameter, 35 mm.

Locality.—1135, Tirangi.

Differs from *A. robusta* Marwick in the much greater development of the parietal callus.

Marginella whitecliffensis n. sp. (Plate 74, fig. 11.)

Shell small, broadly oval, strong. Spire low, conic. Whorls 4, including protoconch which is flatly domed; spire-whorls flat to slightly concave; body-whorl strongly convex with flattened shoulder. Sutures noticeably impressed. Surface smooth and shining, with weak growth-ridges. Aperture long and narrow, widening below, rounded at extremity and emarginate. Outer lip not ascending, with strong varix tapering to sharp edge, smooth within, with fairly deep sinus on shoulder. Columella with 4 strong folds, three lower ones oblique, upper well separated, transverse. Inner lip thick, with well-defined outer edge, separated along its lower portion by shallow depression from weak basal limb formed by anterior border of aperture.

Height, 6 mm.; diameter, 4·5 mm.

Locality.—1129, White Cliffs.

Turricula waitaraensis n. sp. (Plate 74, fig. 9.)

Shell large, fusiform. Spire pagodiform, over half height of aperture and canal. Whorls strongly angled, with broad gently sloping shoulder and contracted sides; body-whorl with shoulder much steeper, angulation still strong and projecting, below this body tapers very slowly, then more quickly; anterior end broken. Sculpture: weak spiral threads with wide interstices each containing a secondary spiral, on spire-whorls and upper part of body spirals are scarcely discernible, angle furnished with strong cord, growth-lines also almost absent so that sinus on shoulder not always clearly marked. Suture plain. Aperture large, angled above. Outer lip thin, deeply notched above, the sinus having a long outer side and short inner one, apex rounded, one-third across shoulder from suture. Inner lip thinly calloused.

Height (estimated), 65 mm.; diameter, 33 mm.

Locality.—1148, Mangare Road, half a mile south of big tunnel, Upper Waitara Survey District. Generic location provisional (see remarks under *Mangilia taranakiensis*).

Inquisitor asper n. sp. (Plate 74, fig. 7.)

Shell small, fusiform. Spire rather higher than aperture and canal. Whorls angled above middle with concave steep shoulder, straight sides; body contracted rather quickly on base to somewhat short neck. Sculpture: strong rounded axial ribs, 12 on spire-whorls and 13 on body, they cease abruptly at periphery of shoulder, forming rounded nodules, but extend anteriorly across body-whorl well below line of suture; spire-whorls with broad double spiral on shoulder-angle and a narrower one close below; on body are 4 more spirals, upper 3 strong with slightly wider interstices; where spirals cross ribs they are raised into low nodules, ribs do not extend down to lowest two spirals, which are therefore plain. Suture strongly bordered below. Aperture oval, produced below into a rather short canal. Outer lip thin, with a fairly deep and narrowly rounded sinus in the middle of the shoulder, convex below.

Height, 14 mm. (estimated); diameter, 6 mm.

Locality.—Okoke Road, 60 chains west of Pehu Trig., Upper Waitara Survey District.

Distinguished from *I. wanganuiensis* (Hutton) and *I. chordata* (Sut.) by the anterior extension of ribs on body-whorl, also by the arrangement of the spirals.

Turricula curtata n. sp. (Plate 74, fig. 8.)

Shell of moderate size, broadly fusiform. Spire turreted, two-thirds height of aperture and canal. Whorls strongly angled, with broad slightly concave almost horizontal shoulder and straight sides; body with shoulder quite strongly concave and sloping, below which it contracts quickly with a slight convexity to a short gently-twisted canal. Sculpture of 16 rounded axial ribs per whorl, weakening below but extending well down body, practically stopping above at periphery of shoulder and giving an appearance of tuberculation; whole surface with rather flattened strong spirals, 4 or 5 on sides of spire-whorls and about 8 weaker ones on shoulder, body with 9 or 10 on shoulder and about 20 or 22 below, upper 8 with wide interstices each containing secondary thread; all spirals and interstices crossed by fine regular well-marked growth-striae. Aperture oval, channelled above, produced below into rather short twisted canal not notched at base. Outer lip thin, with a broad arcuate sinus extending from suture to periphery, below which it is regularly convex. Columella smooth. Inner lip calloused, not definitely limited.

Height, 20·5 mm.; diameter, 12 mm.

Locality.—1141, coast for one mile south of Wai-iti Stream, Mimi Survey District.

Generic location provisional (see remarks under next species).

Mangilia taranakiensis n. sp. (Plate 74, fig. 5.)

Shell small, broadly fusiform. Spire turreted, equal in height to aperture and canal. Protoconch fairly large, of about 2 smooth turbinate whorls. Post-embryonic whorls about 4½, on spire sharply angled above middle with broad almost flat shoulder; body-whorl also strongly shouldered, contracted below rather quickly then straightening out to short slightly twisted neck bearing well-marked fasciole. Sculpture: 12 to 14 strong axial ribs which stop suddenly at periphery, forming short sharp tubercles, they weaken as they extend across base of body but reach almost

to fasciole; spire-whorls have 2 or 3 spiral cords on sides and 1 on periphery, body-whorl has 14 cords from angle to fasciole, 3 weaker ones to outer half of shoulder and 3 very weak ones on fasciole; growth-lines not well marked until near aperture. Aperture oval, angled above, produced below into short broad sloping canal rather deeply notched at base. Outer lip thin, retracted from suture to periphery thence very slighly convex. Columella smooth, short, strongly bent at junction with canal. Inner lip rather thick, forming with fasciole shallow groove.

Height, 6 mm.; diameter, 4 mm.

Locality.—1134, Papatiki Stream.

With the exception of *Inquisitor asper*, the generic location of the Turridae described above is quite provisional. New genera seem to be required; but Mr. H. J. Finlay is at present investigating the family, and so will be able to speak more authoritatively on the matter.

Terebra omahuensis n. sp. (Plate 74, fig. 3.)

Shell of moderate size, subulate. Spire of 8 convex whorls; body-whorl regularly rounded, contracting quickly to short neck bearing strong fasciole bounded by ridge. Sculpture: 20 to 24 rather weak irregular convex axial ribs with slightly narrower interstices, very weak on base of body, interstices with scattered indications of spiral threads. Aperture oval with broad, short, deeply-notched anterior canal.

Height, 22 mm.; diameter, 7 mm.

Locality.—1126, coast from Tongaporutu River to Omahu Trig.

Distinguished from *T. tristis* Desh. by having half as many more, and weaker, axial ribs.

Ringicula torquata n. sp. (Plate 74, fig. 10.)

Shell small, ovate. Spire turreted, over half height of aperture. Protoconch of about 2 smooth whorls with flattened and tilted apex. Spire-whorls convex; body-whorl inflated, with very quickly contracted base. Suture impressed, bordered. Sculpture: a strong smooth spiral cord borders suture below; spire-whorls and upper part of body almost smooth, with indications of fine spiral lines; lower part of body with 8 or 9 incised spiral grooves with wide interspaces, the former pitted by growth-ridges; upper grooves very weak and blending with smooth space. Outer lip broken, so apertural characters not clear. Columella has 2 strong narrow well-spaced folds, lower one stronger. Inner lip forming thick pad on parietal wall and bearing another fairly strong fold; much of upper part of lip broken, so full development not seen.

Height, 4 mm.; diameter, 2·5 mm.

Locality.—1134, Papatiki Stream.

Easily distinguished by the strongly-bordered impressed suture.

Dentalium otamaringaensis n. sp. (Plate 74, fig. 15.)

Shell large and strong, tapering rather quickly. Posterior end curved gently; anterior end almost straight. Sculpture: 20 to 24 strong longitudinal ribs narrower than interstices at posterior end but broadening with age until they are from 2 mm. to 3 mm. across at anterior end, and have linear interstices; whole surface with extremely fine secondary longitudinal threads, they are crossed by microscopic concrescent growth-lines on anterior, but in youth these are much stronger and make the shell

rugose. Aperture oblique; cross-section of shell at first circular, later compressed laterally to a trifling extent.

Length, 97 mm. (imperfect); diameter of anterior, 18 mm.

Locality.—1146, mouth of Waiau Stream east to Otamaringa Pa, Waitara Survey District.

The ribs are much broader and fewer in number than those of *D. solidum* Hutton.

Nucula ruatakiensis n. sp. (Plate 75, figs. 7, 9.)

Shell small, thin, subcircular, moderately inflated. Beaks low, broad, slightly behind middle. Posterior and lower margins regularly arcuate; anterior narrowly convex. Lunule long and broad. Escutcheon fairly large, projecting somewhat, bounded by shallow groove. Sculpture: fine rounded radial ribs, 9 per millimetre, crossed by numerous concentric growth-stages; these radials not developed on escutcheon or on anterior area, place being taken by much finer divaricate striae, about 18 per millimetre. Hinge narrow, with 12 slightly sagittate anterior teeth and 11 short straight posterior ones: resilifer broken but apparently small. Valve-margins crenate, corresponding to radials (*i.e.*, extremely fine in hinge region, coarser in ventral region).

Height, 5·1 mm.; length, 5·5 mm.; diameter (one valve), 1·6 mm.

Locality.—1141, coast for one mile south of Wai-iti Stream, Mimi Survey District.

This species does not seem to be closely related to any other New Zealand one so far described.

Nucula otamaringaensis n. sp. (Plate 74, figs. 13, 14.)

Shell very large, oval, inflated. Beaks incurved, approximate and directed strongly backward, situated about posterior fourth. Anterior dorsal margin long, slightly convex, descending gradually to somewhat narrow anterior margin; posterior margin regularly convex. Lunule well defined by broad shallow groove bounding outside of a low narrow ridge. Escutcheon deeply sunk below umbones. Sculpture: fine fairly regular concentric ridges crossed by equally fine radials, on anterior area concentric sculpture becomes obsolete and radial element prevails. Hinge not seen. Valve-margins bevelled, smooth.

Height, 23 mm.; length, 29 mm.; thickness (one valve), 10 mm.

Localities.—1146, mouth of Waiau Stream east to Otamaringa Pa, Waitara Survey District; 1148, Mangare Road, south of big tunnel, Upper Waitara Survey District.

Nucula grangei n. sp. (Plate 74, figs. 1, 4.)

Shell small, rounded triangular, inflated, strong. Umbo at posterior third broad and high. Anterior end somewhat narrowly rounded, with curved descending dorsal margin; posterior end subangled. Lunule broad, flattened, not well defined. Escutcheon bounded by broad low ridge, within which it is concave but then raised into high pouting margin. Surface practically smooth, with a few obsolete concentric ridges. Hinge broad, with about 12 posterior and 14 anterior teeth. Valve-margins smooth.

Height, 6 mm.; length, 6·5 mm.; diameter (one valve), 2 mm.

Locality.—1125, coast between Waikiekie and Mangapuketea Stream, Mimi Survey District.

Nuculana ellisi n. sp. (Plate 75, figs. 12, 14.)

Shell large, suboval, thick and strong. Umbo broad and high, slightly in front of middle. Anterior end long, narrowly rounded; posterior end drawn out to a narrow, oblique, bluntly-truncated end. Lunule large, slightly concave, defined by absence of concentric sculpture. Escutcheon also large and not crossed by concentric ribbing, bounded by low rounded ridge which extends to posterior extremity of shell, and traversed by low median ridge. Sculpture: sharply bevelled close concentric ridges, 3 to 3½ per millimetre, anastomosing on posterior. Hinge strong, with 12 anterior and about 14 posterior chevroned teeth, resilifer broadly triangular. Pallial sinus shallow.

Height, 8 mm.; length, 14 mm.; diameter (one valve), 3·5 mm.

Locality.—1127, Waikiekie Stream.

Nuculana onairoensis n. sp. (Plate 75, figs. 17, 19.)

Shell fairly large, greatly inflated, test thin. Beaks broad and high, slightly in front of middle. Anterior end somewhat narrowly convex: posterior tapering rapidly to sharp beak slightly upturned. Lunule not marked off. Escutcheon very broad, concave, bounded by rounded ridge and with another broad rounded median ridge, between this and umbo valve-margin raised into prominent convexity. Sculpture of strong regular bevelled concentric ridges, about 5 per millimetre, becoming weak in lunular region and on crossing ridges bounding escutcheon. Interior not seen.

Height, 8 mm.; length, 11·5 mm.; diameter (one valve), 3·5 mm.

Locality.—1146, mouth of Waiau Stream east to Otamaringa Pa, Waitara Survey District.

Zealeda mutabilis n. sp. (Plate 75, fig. 16.)

Shell minute, suboval, inflated. Umbo median, broad and low. Anterior end regularly convex; posterior end with a projecting humped proboscis suddenly contracted below to a regularly rounded ventral margin; a high rounded ridge runs from extremity of proboscis to umbo. Sculpture: up to almost 1 mm. diameter shell has only microscopic concentric lines, but from there to within 0·6 mm. of margin there are relatively strong wrinkle-like radials, 10 on each side of almost smooth central part, which has about 5 obsolete radials, when new ribs appear they do so suddenly, causing prominent divergencies, and giving a divaricate appearance to sculpture; on outer 0·6 mm. of diameter are 4 strong concentric folds interrupting the radials, which, however, appear, though much weakened, in interstices of folds.

Height, 1·8 mm.; length, 2·5 mm.; diameter (one valve), 0·75 mm.

Locality.—1125, between Waikiekie and Mangapuketea Streams.

Distinguished from *Z. hamata* Marwick by the smaller size, concentric ridges towards margin, and radials on posterior.

I am indebted to Mr. B. B. Woodward for information by letter that Dr. W. H. Dall considers *Zealeda* synonymous with his *Spinula*. The American shell has not such a peculiarly humped proboscis, nor any radial sculpture, and is many times larger; therefore close relationship seems unlikely.

Malletia (Minormalletia) tenera n. sp. (Plate 75, fig. 8.)

Shell small, broadly oval, thin, fragile. Umbo broad and low, between middle and anterior third. Anterior end rounded; ventral margin broadly

convex; posterior produced, broadly and rather roundly truncated with a straight dorsal margin. Surface smooth and polished, but a lens shows very weak fairly regular spaced concentric ridges. Hinge narrow, armed with numerous extremely fine taxodont teeth.

Height, 5 mm.; length, 7 mm.; diameter (one valve), 1 mm.

Locality.—1127, Waikiekie Stream, Mimi Survey District.

The test is so fragile that a successful excavation of the hinge could not be made. A paratype shows some of the teeth, but not the region under the umbo.

Neilo waitaraensis n. sp. (Plate 75, figs. 2, 5.)

Shell small, suboval. Umbo low and broad, slightly in front of middle. Anterior end rather narrowly rounded; ventral margin broadly convex; posterior end produced, broadly truncated, with a straight slightly descending dorsal margin. Neither lunule nor escutcheon well defined, latter sometimes with low central ridge. Posterior area concave. Sculpture of regular fine close concentric ridges with bevelled sides and sharp summits. Hinge with about 16 taxodont teeth on each side. No resilifer.

Height, 6 mm.; length, 8 mm.; diameter (one valve), 2·5 mm.

Locality.—1142, 30 chains south-south-west from junction of Tangitu with Waitara River.

Neilo sublaevis n. sp. (Plate 75, fig. 11.)

Shell of moderate size to large, sub-oblong. Umbo about anterior third, broad, rather low. Anterior end somewhat narrowly convex; posterior end produced, broad, obliquely truncated at extremity; dorsal margin long, straight, horizontal; rounded ridge runs from umbo to posterior end of ventral margin bounding prominent concave posterior area. Lunule very long and narrow. Escutcheon also long and narrow, deeply sunk, and furnished with a sharp median ridge. Surface almost smooth but with obsolete concentric ridges getting stronger on anterior end.

Height, 15·5 mm.; length, 27 mm.; diameter (one valve), 6 mm. (Some specimens are 40 mm. in length.)

Locality.—1125, coast between Waikiekie and Mangapuketea Streams, Mimi Survey District.

Easily distinguished from *N. australis* by the almost smooth surface, less attenuated shape, much deeper escutcheon, &c. *Neilo* has generally been placed as a subgenus of *Malletia*, but the different shape, equal development of anterior and posterior teeth, and short pallial sinus justify full generic rank.

Lima watersi n. sp. (Plate 74, fig. 12.)

Shell of moderate size, little inflated, oblique. Sculpture: 22 low rounded ribs with interstices equal or wider, ribs flattening out towards margin, growth-lines weak except towards margin, ribs bear scattered scars where probably spines were attached. Submargin deep, with only 1 or 2 weak radials, and well-marked growth-lines. Ears narrow. Ligamental area somewhat narrow and high, with a pit occupying one-third its area.

Height, 49 mm.; length, 42 mm.; diameter (one valve), 10 mm

Locality.—1139, Uruti.

Venericardia urutiensis n. sp. (Plate 75, figs. 1, 3.)

Shell of moderate size, suboblong. Beaks at anterior fourth. Dorsal margin long, straight, gently descending; posterior end obliquely truncated; ventral margin broadly curved, ascending more quickly in front to meet the regular convex anterior margin. Lunule lanceolate, impressed. No escutcheon. Sculpture: 24 radials narrow in front and on posterior area, broad and rounded on centre of disc, with narrow interstices. Left valve with a strong triangular cardinal under the umbo and a long straight high posterior cardinal parallel to the ligament. Right valve with a long strong triangular oblique median cardinal; anterior cardinal low, separated from lunule by a shallow groove; posterior cardinal long and narrow. Nymphs also long and narrow. Valve margins crenulated.

Height, 20 mm.; length, 28 mm.; diameter (one valve), 8 mm.

Locality.—1139, Quarry, Uruti, one mile west of post-office.

The ribs of the holotype are smooth, but this is probably due to imperfect preservation, for topotypes show fairly high rounded ribs with close nodules on anterior of shell, central ribs with the nodules degenerated into irregular growth-ridges.

Lucinida tirangiensis n. sp. (Plate 75, fig. 18.)

Shell large, circular, winged posteriorly, moderately inflated, rather thin. Lunule narrowly lanceolate, in front of it a depressed expanded wing, somewhat variable in size. Sculpture: up to 15 mm. diameter, regular narrow concentric ridges, about 2 per millimetre, the interstices of well-preserved specimens with fine radial threads separated by wide interspaces; later sculpture is of irregular growth-lines generally well separated and often showing radials. Hinge not exposed in any of the specimens. Valve-margins smooth.

Height, 32 mm.; length, 33 mm.; diameter (one valve), 9 mm.

Locality.—1135, Tirangi Stream.

Closely related to *L. dispar* (Hutton), but distinguished by its larger size, close regular spirals on a considerable part of disc, and coarser more separated radials.

Myrtaea (Eulopia) papatikiensis n. sp. (Plate 75, figs. 4, 6.)

Shell small, suboval, little inflated. Umbo almost central. Anterior dorsal margin straight, descending gradually; anterior end vertical, rounded below; ventral margin broadly convex; posterior margin similar in shape to anterior but slightly longer. Lunule long, very narrow, sunken. Escutcheon also long and narrow, bounded by rugose ridge. Sculpture of sharp well-spaced concentric ridges, 4 per millimetre; interspaces with microscopic somewhat irregular radial threads. Hinge of left valve with 2 small cardinal teeth, and a distant posterior and anterior lateral, latter stronger. Right valve with a median cardinal and a distant posterior lateral, anterior broken but probably stronger. Adductor impressions rather small: anterior broadly rounded above, constricted slightly in middle, then contracted quickly and finally tapering narrowly to pallial line; posterior scar oval. Pallial line is broad in type, but this may be due to peeling of inner layer of shell.

Height, 6 mm.; length, 5 mm.; diameter (one valve), 1 mm.

Locality.—1134, Papatiki Stream.

Thyasira planata n. sp. (Plate 75, figs. 10, 13.)

Shell small, suborbicular. Umbo at anterior third. Anterior end concave above, narrowly rounded below; posterior end winged; a strong furrow with convex anterior side proceeding from umbo to lower part of posterior margin, another with an angular anterior margin runs from umbo to upper part of posterior margin. Lunule large, sunken, lanceolate, well defined. Sculpture of obsolete irregular concentric ridges and folds, whole surface with regular, sharp, close, microscopic growth-lines. Interior not seen.

Height, 9 mm.; length, 10 mm.; diameter (one valve), 3·5 mm.

Locality.—1127, Waikiekie Stream.

Distinguished from *T. flexuosa* by well-defined lunule, sharper posterior ridges, and less inflation.

Leptomya simplex n. sp. (Plate 75, fig. 15.)

Shell small, ovate, thin. Umbo median, inconspicuous. Anterior end regularly convex; dorsal margin descending; posterior end tapering to obliquely and roundly truncated extremity. Sculpture of narrow distant concentric low lamellae, interspaces crowded with fine radial threads.

Height, 7 mm.; length, 9 mm.; thickness (one valve), 1·5 mm.

Locality.—1125, coast between Waikiekie and Mangapuketea Streams.

Distinguished from *L. perconfusa* Iredale by the greater height compared with length, and the absence of a posterior ventral sinus.

Geology of Upper Waitotara Valley, Taranaki.

By L. I. GRANGE, M.Sc., F.G.S., N.Z. Geological Survey.

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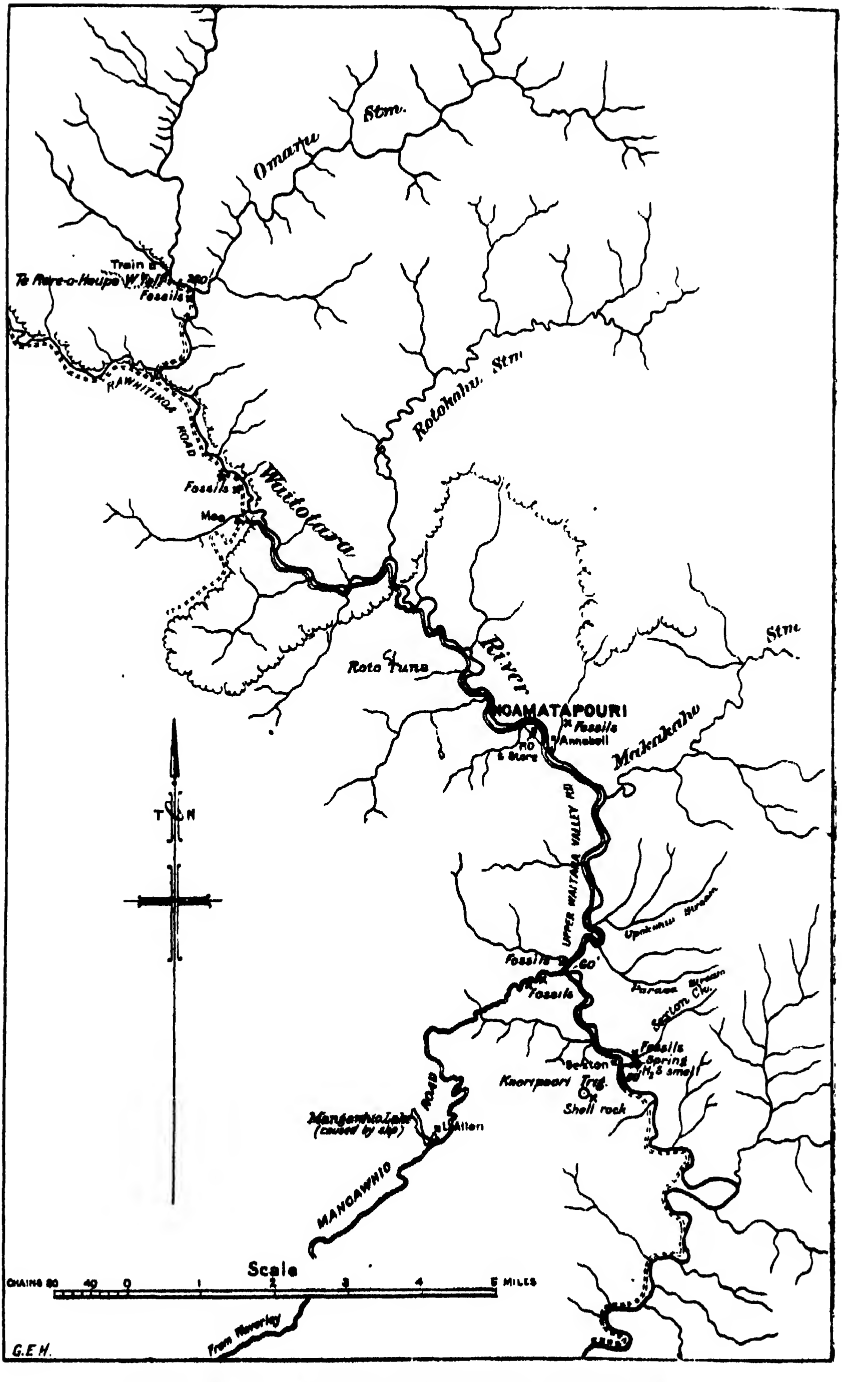
DURING September, 1923, the writer spent a week at Ngamatapouri and Kapara, in the Waitotara Valley, and partly explored the geologically unknown area lying between the coastal strip west of Wanganui examined by Marshall and Murdoch (1920 and 1921) and the Tongaporutu–Ohura Subdivision (see *N.Z. Geol. Surv. 17th Ann. Rep.*, Parl. Paper C.–2c, pp. 3, 7–8, 1923). Ngamatapouri Township, in the centre of the district, is about twenty-two miles north-east of Patea.

The writer is indebted to the Geological Survey for the determination of the fossils he collected, and also for permission to examine Professor James Park's collection from the Wanganui River, made in 1887. He also wishes to acknowledge the assistance given by Messrs. J. R. Annabell and G. H. Sexton, of Ngamatapouri, and Mr. G. Mee, of Kapara. Mr. G. E. Harris kindly drew the accompanying sketch-map.

Most observers in Taranaki have noted the accordant heights of the ridges. Up-stream from Ngamatapouri the main ridges range between 1,400 ft. and 1,700 ft. above sea-level. They are probably the inter-stream upland spaces of a mature surface, into which the drainage-channels have entrenched deeply. At the junction of Mangawhio Road with Waitotara Valley Road the river is approximately 60 ft. above sea-level, and at Te Rere-o-Haupa Waterfall, some twelve miles farther up the valley,



WAITOTARA VALLEY NORTH AND SOUTH OF NGAMATAPOURI.

about 250 ft. This dissection has been due to rejuvenation of the streams by uplift. Of the lakes that occur in the branch streams the writer had an opportunity of observing only the Mangawhio Lake. This has been formed by a portion of the hillside damming the valley by breaking away and sliding forward across the stream-bed.

Excepting alluvial deposits, the only beds outcropping in this area are Tertiary rocks consisting of sandstones, arenaceous mudstones, shelly limestones, and conglomerates. From Waitotara Township almost to the northern end of Mangawhio Road the beds are sandstones with no appreciable dip. At the end of the Mangawhio Road mudstone appears under the sandstone a little above road-level. Owing to a dip of about 2° to the south-west, the line of contact rises up-stream at least as far as the mouth of Rotokohu Stream. Up-stream from this point most of the land is covered with bush; the few outcrops that were observed indicate that the beds are sandy and lie fairly flat. Shelly limestone outcrops at many points about road-level between the mouth of Rotokohu Stream and Te Rere-o-Haupa Waterfall, at a few chains east of Kaoripaori Trig., and near the mouth of the branch of the Waitotara entering from the east opposite Mr. Sexton's house. Shelly conglomerate, about 20 chains north-east of Mr. Annabell's house, contains small pebbles of argillite and greywacke.

Fossils collected from several localities have been identified by Dr. J. Marwick. They appear to be of Waitotaran (Lower Pliocene) age. The following Mollusca were obtained from sandstone and shelly conglomerate near the mouth of the branch of the Waitotara entering from the east opposite Mr. Sexton's house. This stream has a local name which should not be adopted, and the writer proposes to call it Sexton Creek.

†*Alcithoe morgani* (Marsh. & Murd.)
**Anomia trigonopsis* Hutt.
**Atrina zelandica* (Gray).
Barnea n. sp.
Cardium spatiosum Hutt.
Crepidula incurva Zitt.
Dentalium solidum Hutt.
**Divaricella cumingi* Ad. & Ang.
Dosinia n. sp.
Drillia n. sp.
†*Glycymeris manaiaensis* Marwick
†*Miltha neozelanica* Marsh. & Murd.
Olivella neozelanica Hutt.
†*Ostrea ingens* Zitt.
†*Pecten triphooki* Zitt.
†*Polinices ovuloides* Marwick
Tellina n. sp.
**Turritella rosea* Q. & G.
**Verconella mandarina* (Duclos)
Xymene oliveri Marwick

In the above and following lists an asterisk indicates that the species is still living; a dagger that it is elsewhere found only on the Waipipi beds, which are considered to extend along the coast from Waipipi Beach to Hawera.

In a block cutting about 20 chains north of the junction of Mangawhio and Upper Waitotara Valley roads †*Pecten crawfordi* Hutt. and †*P. triphooki* Zitt. were collected.

The shelly conglomerate north-east of Mr. Annabell's house yielded—

Aethocola n. sp.
†*Aethocola* sp. (spire same as Patea specimen)
**Amphidesma subtriangulatum* (Wood)
Ancilla cf. *australis* (Sowb.)
**Ancilla novae-zelandiae* E. A. Smith
†*Ancilla* n. sp. cf. *hebera* (Hutt.)
Ataxocerithium n. sp.
Barnea n. sp.
Callanaitis n. sp. cf. *speighti* (Sut.) ?
**Calyptraea tenuis* (Gray)
Cerithidea n. sp.
**Chione stutchburyi* (Gray)
**Cominella lurida* (Phil.)
Crepidula incurva Zitt.
Dosinia sp.
†*Glycymeris manaiaensis* Marwick

**Mactra discors* (Gray)
**Mactra ordinaria* E. A. Smith
Monodonta sp.
Olivella neozelanica Hutt.
†*Ostrea ingens* Zitt.
†*Polinices ovuloides* Marwick
**Spisula* cf. *aequilateralis* Desh.
Struthiolaria n. sp. cf. *spinosa* Hector
Terebra n. sp. ? (not Recent)
Turbo postulatus Bart.
Umbonium n. sp. cf. *anguliferum* (Phil.) (same as at Waipipi Beach)
Xymene expansus (Hutt.)
**Zenatia acinaces* (Q. & G.)

Turris n. sp. cf. *kaiparaensis* Marsh. was found in a road-cutting 20 chains west from the store at Ngamatapouri.

The following Mollusca were obtained from outcrops of shelly limestone on the road for two miles north of Mr. Mee's house at Kapara :—

†*Ancilla* n. sp. cf. *hebera*
**Anomia trigonopsis* Hutt.
Crepidula incurva Zitt. (very large)
**Glycymeris laticostata* (Q. & G.) (inflated)
**Mactra ordinaria* E. A. Smith
Mydora sp. (inside of left valve)
Mytilus sp.
Paphia (*Ruditapes*) n. sp. (longer than *intermedia*)
Turritella n. sp. (four spirals)
**Venericardia purpurata* (Desh.)
**Zenatia acinaces* Q. & G.

The fossils listed below are from shelly limestone outcropping on the Upper Waitotara Valley Road, between Rawhitiroa Road and the waterfall :—

Atrina sp.
**Calliostoma selectum* (Chemn.)
**Calyptraea tenuis* (Gray) (very large)
Cardium spatiosum Hutt.
Chione cf. *subsulcata* Sut.
Crepidula incurva Zitt.
Dosinia sp.
**Glycymeris laticostata* (Q. & G.)
†*Glycymeris manaiaensis* Marwick
Glycymeris n. sp. (like *manaiaensis* but very inflated)
Lucinida dispar Hutt. ?
**Mactra ordinaria* E. A. Smith
Marcia cf. *sulcata* (Hutt.)
Modiolus sp.
†*Ostrea ingens* Zitt. ?
Paphia (*Ruditapes*) n. sp. (longer than *intermedia* (Q. & G.))
†*Pecten triphooki* Zitt.
**Protocardia pulchella* (Gray)
Turritella n. sp. cf. *fulminata* Hutt.
**Venericardia purpurata* (Desh.)
**Zenatia acinaces* (Q. & G.)

The reference of the beds containing these fossils to their position in the classification appended below of Tertiary strata in Taranaki and west Wellington presents no difficulties.

Beds in Taranaki and West Wellington.	Stage Name.	Group Name.
Castlecliff beds	Castlecliffian‡	Wanganuian.‡
Nukumaru beds..	Nukumaruan§ ..	Wanganuian.‡
Waipipi beds	Waitotaran‡	Wanganuian.‡
Onairo beds	Taranakian	Taranakian.‖
Tongaporutu beds	Taranakian	Taranakian.‖
Mokau and Mohakatino beds ..	Awamoan‡	Oamaruian.‡

‡ Thomson's stage and group names. See *Trans. N.Z. Inst.*, vol. 48, pp. 28–40, 1916. It is stated in *N.Z. Geol. Surv. Pal. Bull. No. 10*, p. 48, that the Waitotaran stage may be divided into the Nukumaruan and Waipipian; but this cannot be done, for Thomson in the paper cited above does not include the Nukumaru beds in the Waitotaran.

§ See J. Marwick, *Trans. N.Z. Inst.*, vol. 55, p. 191, 1924.

‖ The reasons for making the Tongaporutu and the Onairo series (as employed in *N.Z. Geol. Surv. 17th Ann. Rep.*, p. 7) a new group are detailed in the bulletin on the Tongaporutu-Ohura Subdivision, now in preparation.

On field evidence the beds from Sexton Creek, close to the junction of Mangawhio and Upper Waitotara Valley Roads, near Mr. Annabell's, and near Ngamatapouri, belong to one horizon. The common shells at this horizon—*Alcithoe morgani*, *Cardium spatiosum*, *Glycymeris manaiaensis*, *Miltha neozelanica*, *Olivella neozelanica*, *Ostrea ingens*, *Pecten crawfordi*, *P. triphooki*, and *Polinices ovuloides*—are also common in the Waipipi beds* and are not found in the younger beds; also, eight species have hitherto been found only in the Waipipi beds. Of the remainder, fourteen are new species; and, of the other twenty-eight, those that are not new species occur also in younger beds—Castlecliffian or Recent. The above evidence indicates that the beds are Waitotaran. In the field the stratigraphic position of the strata near Kapara and the waterfall in relation to those down-stream is uncertain. Since the beds at these two localities contain forms which are either new species or occur in the Waitotaran, they also can be correlated with the fossiliferous beds of the Waitotaran. On the other hand, the above conclusions do not agree with that obtained by the percentage method of correlating. The total fauna from this district contains fifty-three species, of which seventeen, or 32 per cent., are still living, whereas 48 per cent. of the fossils in the Waitotaran in the coastal section are Recent. This difference may be due to the smaller fauna from Waitotara Valley, for, since the extinct species, as it happens, are the common shells, further collecting may increase the percentage of Recent ones.

Since the bed of the river from Te Rere-o-Haupa Waterfall rises fairly rapidly to its headwaters, it is unlikely that beds lower than the Waitotaran occur farther up the Waitotara Valley than the part examined by the writer.

A collection made by Park (1887) from the limestone caves near Mangaio (fifteen miles north-east of Ngamatopouri), on the Wanganui River, about four miles above Pipiriki, is probably from the Waitotaran. The fossils, identified by Dr. Marwick, are:—

**Calyptraea tenuis* (Gray) (large)	*Olivella* sp.
**Dosinia subrosea* (Gray)	**Protocardia pulchella* (Gray)
Glycymeris cf. *manaiaensis* Marwick	**Solariella egena* (Gould)
**Mactra ordinaria* E. A. Smith	**Solariella* n. sp. near *egena* (Gould)

All these except the *Solariella* are abundant in the Waitotaran. *Solariella egena* is not found on the coast below the Castlecliff beds. Thus the area occupied by Wanganuian strata in south Taranaki and west Wellington can be extended from the coast-line in a northerly direction roughly to a line stretching from Hawera to the headwaters of the Waitotara, and across to the Wanganui River a few miles above Pipiriki.

The nearest point where the writer has collected fossils from the Onairo series to the fossil localities near the head of the Waitotara is in the Whangamomona Stream, below Whangamomona Township, distant sixteen miles due north. It would be interesting to explore the unmapped area between the head of the Waitotara and the Whangamomona in order to ascertain the relation of the two groups of strata. Unfortunately, this area is rugged, and for the most part covered by bush.

There is a cold spring about 2 chains from the mouth of Sexton Creek; it is about 9 ft. away from and about 3 ft. above the bank. The spring

* Many of the facts concerning the Waipipi beds were supplied by Dr. J. Marwick.

has a flow of a few gallons per minute, and smells strongly of sulphuretted hydrogen. The water was analysed by the Dominion Analyst, with the following result:—

	Parts per 100,000.
Silica (SiO_2)	2·00
Aluminium (Al)	0·60
Iron (Fe)	0·07
Calcium (Ca)	4·30
Magnesium (Mg)	1·30
Sodium (Na)	3·05
Chlorine (Cl)	4·25
Sulphuric-acid ion (SO_4)	10·10
Carbonic-acid ion (HCO_3)	11·50
Total solids	37·17
Ionic sulphur (S)	0·019
Ionic hydrogen (H)	0·001

These may be combined as follows:-

Sodium silicate ($Na_2O.4SiO_2$)	2·5
Aluminium sulphate ($Al_2(SO_4)_3$)	4·0
Iron bicarbonate ($FeH_2(CO_3)_2$)	0·2
Calcium sulphate ($CaSO_4$)	9·5
Calcium bicarbonate ($CaH_2(CO_3)_2$)	6·0
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	8·0
Sodium chloride (NaCl)	7·0
	37·2
Hydrogen sulphide	0·02

Sulphuretted hydrogen is not uncommon in springs of meteoric origin, and where rising through marine sedimentary rocks is most probably formed by the action of acid waters on iron sulphide (Clarke, 1920). Cunningham Craig (1914) points out that in many oilfields it is formed by the action of water upon sulphur compounds in the petroleum. As an isolated occurrence it has no value as an oil-indication.

Literature cited.

1887. J. Park, On the Upper Wanganui and King-country. *Rep. Geol. Explor. during 1886–87*, vol. 18, pp. 171–72.

1914. E. H. Cunningham Craig, *Oil-finding* p. 108.

1920. F. W. Clarke, Data of Geochemistry. *U.S. Geol. Surv. Bull. 695*, p. 579.

1920. P. Marshall and R. Murdoch, Tertiary Rocks near Wanganui. *Trans. N.Z. Inst.*, vol. 52, pp. 115–28.

1921. P. Marshall, Tertiary Rocks near Hawera. *Trans. N.Z. Inst.*, vol. 53, pp. 86–96.

Significance of Fossils from the Huiroa Oil-bore, Taranaki.

By L. I. GRANGE, M.Sc., F.G.S., N.Z. Geological Survey.

[*Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 10th October, 1923; received by Editor, 6th October, 1924; issued separately, 31st March, 1926.*]

THREE shells from between the depths of 4,550 ft. and 4,760 ft. in the Huiroa oil-bore (twenty-four miles south-east of New Plymouth, or fifteen miles by a road north-east of Stratford), forwarded to the Geological Survey in 1916 by Mr. J. Henchman, and identified by Mr. H. Suter,* are now classed by Dr. Marwick† as—

Aethocola cliftonensis Marwick,
Streptopelma henchmani Marwick,
Turritella carlottae Watson (still living).

These fossils can be used to refer the beds from which they came to their place in the Tertiary succession recognized in Taranaki (see p. 317). The most important for this purpose is *Streptopelma henchmani*,‡ which has been collected by the writer on the coast between Pukearuhe and the mouth of Onairo Stream—the only locality besides the bore in which it is known to occur—in beds belonging to the lower 1,400 ft. of the Onairo series. *Aethocola cliftonensis* ranges from the Onairo series down to the underlying Tongaporutu series, and the Recent species *Turritella carlottae*, according to Dr. Marwick, also ranges down to the Tongaporutu series. The above evidence thus indicates that the bottom of the well, at 4,921 ft. (or about 4,250 ft. below sea-level), is probably still in the Onairo series, though possibly in the Tongaporutu series. The stratigraphical evidence tends to place the bottom of the bore at least as low as the base of the former series.

Since at New Plymouth only the Onairo beds have yielded oil—deep boring into older strata having so far proved unsuccessful—a knowledge of the position of the base of the Onairo series will be of use in testing this known petroliferous series in other parts of Taranaki. About 2,000 ft. of Onairo beds is exposed on the coast as far west as a point six miles east of the mouth of the Waitara; and if roughly the same dip is maintained, and no big faults displace the strata, the base of the series lies at about 4,000 ft. below sea-level at New Plymouth. A line drawn south-east from New Plymouth to a point a little to the north-east of the Huiroa bore is believed to indicate approximately the base of the Onairo series at 4,000 ft. below sea-level. To the north-east it lies at shallower depths, reaching sea-level at the southern end of White Cliffs.

Any fossils, even if fragmentary, obtained during drilling in Taranaki are of interest, and some may be of value in determining the position of the beds penetrated.

* *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 24, 1921.
† For description of the first two species see paper by Dr. Marwick at page 321.
‡ Termed *Verconella* n. sp. in *N.Z. Geol. Surv. 17th Ann. Rep.*, Parliamentary Paper C.-2c, p. 8, 1923.

Fossil Mollusca from the Waihao Greensands.

By R. S. Allan, M.Sc., Otago University.

[*Read before the Otago Institute, 9th December, 1924; received by Editor, 31st December, 1924; issued separately, 31st March, 1926.*]

Plates 76, 77.

The present paper deals with fossils collected in the Waihao area. The writer is greatly indebted to Mr. H. J. Finlay and to Dr. J. Marwick for help in connection with nomenclature.

Family APORRHAIDAE Philippi.

Perissoptera (Hemichenopus) thomsoni n. sp. (Plate 76, fig. 1.)

This interesting shell is, unfortunately, very incomplete, only the spire being preserved. Dr. Marwick has kindly examined if for the writer; he remarks, "The gasteropod is certainly an Aporrhaid, belonging to the same group as *Dicroloma*, but without the complete aperture it would be hard to say which genus it most resembles. *Hemichenopus* Steinmann and Wilckens is a Magellanian Tertiary subgenus of *Perissoptera*, which may have to be considered. Dr. Marshall say he does not think it is *D. zelandica* Marshall, the whorls being less convex. *Hemichenopus* differs from *Perissoptera* in having only spiral ornament, and in this respect your shell is of intermediate development; but until the aperture is known it would be rash to lay much weight on the generic affinities."

A description of the spire is as follows:—

Six early whorls and a worn featureless protoconch are preserved. Whorls rapidly increasing in size. Older whorls almost straight, slightly concave above, slightly convex below, ornamented with close even spiral cords about 20 per whorl, interstices of same width with very fine spirals; keel obsolete. Earlier whorls becoming strongly keeled immediately above well-marked suture. Keel ornamented with oblique nodules which become more prominent towards protoconch. Spiral cords crossed by oblique curved growth-lines. Spire-angle 40°. Length of first six whorls 22 mm.: width of sixth whorl, 13 mm.

Locality.—Waihao Downs (Bortonian).

In a paper read before the Australasian Association for the Advancement of Science, 1924, the writer has proposed the new stage name Waimateian for the period represented by the Waihao greensands—*i.e.*, pre-Waiarekan. Further, the Waimateian stage has been subdivided into—(*a*) the Tahuian substage, with the type locality at McCullough's Bridge, Waihao River; and (*b*) the Bortonian substage, with the type locality at Borton's, Waitaki River. Both substages are based solely on the contained mollusca.

Family ARCHITECTONICIDAE H. and A. Adams.

Architectonica marwicki n. sp. (Plate 76, fig. 2.)

Shell small, discoidal, spire more elevated than *A. ngaparaensis* Suter. Sculpture of many fine nodular spirals, giving a highly ornamented surface; a strong spiral above the suture. Body-whorl with a strong median spiral

rib dividing it into two parts, each of which has three smaller spirals. Periphery strongly keeled, moniliform, nodular ribs crossed by faint radiate growth-lines. Base with nodular spirals, most distinct next to umbilicus. Spire slightly elevated. Protoconch flat, worn. Whorls 5, regularly increasing. Suture inconspicuous. Umbilicus deep with steep sides, showing all the whorls. Aperture broken.

Holotype in author's collection.*

Height, 2 mm.; diameter, 7 mm. (holotype).

Locality.—Waihao greensands, Waihao Downs (Bortonian).

Differs from *A. ngaparaensis* in the more steeply descending umbilicus, completely nodular sculpture, and the more elevated spire.

Family EULIMIDAE Adams.

Eulima waihaoensis n. sp. (Plate 76, fig. 3.)

Shell large, smooth, subulate. Whorls 14, body-whorl large in comparison. Sides almost straight, very slightly convex, suture not marked. Protoconch worn. Ornamentation of faint growth-lines only. Aperture narrowly ovate, entire, angulate posteriorly, slightly wider in front; outer lip sharp, inner lip slightly thickened. Varices quite irregular in development.

Holotype in Dominion Museum, collected by S. H. Cox, 1924, and forwarded to the writer for study by Dr. J. A. Thomson. Paratypes in the author's collection.

Length, 18 mm.; width, 5 mm. (holotype).

Locality.—McCullough's Bridge, Waihao (Tahuian).

Family FASCIOLARIIDAE Adams.

Fusinus modestus Marshall and Murdoch.

Dr. Marshall (*Trans. N.Z. Inst.*, vol. 54, p. 118, 1923) records this species from McCullough's Bridge. I can find no description of this shell, and it appears to be a *nomen nudum* inadvertently introduced by that writer.

Fusinus bensoni n. sp. (Plate 76, figs. 4*a*, 4*b*.)

Shell large, fusiform, with high turreted spire, axially costate and spirally lirate. Sculpture of heavy radiate pointed nodules, strongest about middle of whorl, obsolete above and below suture; 9 nodules on body-whorl. Spiral sculpture of numerous coarse and fine ribs; the most pronounced rib at convexity of whorls, where it crosses the highest point of nodules. Spirals crossed by faint growth-lines. Spire acute, turreted, less than one-third total length. Protoconch worn. Suture deep, slightly undulating. Whorls 6, regularly descending, carinated a little below middle; body-whorl two-thirds entire length, contracted below. Aperture oval, channelled above, with long straight canal. Outer lip moderately thick, angled above, then convex, contracted below, litrate inside. Columella concave above, convex below. Inner lip narrow, nacreous, as a fine cord anteriorly.

* Owing to the departure of the writer to England, and the consequent dispersal of his collection, the holotypes referred to above as "in author's collection" are now deposited in the Finlay collection. The types of the Naticidae and Volutidae mentioned in Dr. Marwick's papers (*Trans. N.Z. Inst.*, vol. 55, pp. 545–79; vol. 56, pp. 259–303) as being in Mr. R. S. Allan's collection are now deposited in the collection of the New Zealand Geological Survey.

Holotype and paratypes in author's collection.

Height, 46 mm.; diameter, 15 mm. (holotype). The largest specimen collected is incomplete, but has a diameter of 22 mm.

Locality.—Waihao greensands, Waihao Downs (Bortonian).

This fine species is named in honour of Professor W. N. Benson, B.A., D.Sc., F.G.S., of Otago University, to whom the writer is greatly indebted.

Fusinus delicatulus (Marshall and Murdoch).

1923. *Verconella delicatula* M. & M., *Trans. N.Z. Inst.*, vol. 54, p. 123, pl. 14, figs. 3, 4.

This species is evidently closely related to *F. solidus*, and may prove to be a synonym of it. The axial sculpture seems rather variable.

Locality.—McCullough's Bridge, Waihao (Tahuian).

Verconella formosa n. sp. (Plate 76, fig. 7.)

The paratype of *Surcula serotina* Suter (*N.Z. Geol. Surv. Pal. Bull. 5.* pl. 6, fig. 15) is clearly a different shell from the holotype (fig. 12, *loc. cit.*). *S. serotina* is described from Waihao Downs, but does not occur at McCullough's Bridge, whereas the paratype is from McCullough's Bridge. Dr. Marwick considers that this new species is identical with Suter's paratype, and places it provisionally under *Verconella.*

Shell of medium size, fusiform, spirally lirate and axially ribbed. Whorls 5, keeled, ornamentation of numerous spiral cords, interstices finely lirate; crossed by axial ribs most prominent at keel; ribs obsolete on base of body-whorl. Growth-lines show a rounded turrid sinus. Suture deep, bordered below by a band without ribs. Protoconch worn, of 2½ whorls; first whorl with numerous small axial ribs. Aperture ovate, anterior canal short (incomplete), open. Outer lip broken; inner lip with thin callus.

Holotype in author's collection.

Length, 20 mm.; diameter, 8 mm. (holotype).

Locality.—McCullough's Bridge (Tahuian).

Verconella spiralis n. sp. (Plate 76, fig. 9.)

Shell moderately small, broadly fusiform; spire turriculated, axially costate and spirally lirate. Sculpture: Protoconch smooth, of 2½ whorls; succeeding whorls with prominent axial ribs running from keel to suture below, these tend to become obsolete near base. Ribs rounded, interstices of same width, 19 on body-whorl. Spiral sculpture of many fine dense ribs, finer ribs alternate with coarser ones. Spire turriculate, half length of aperture. Whorls 4, regularly increasing, keel above middle; slightly convex below keel, rapidly descending to suture above. Body-whorl contracted at base. Suture impressed, margined below by a band without axials. Sinus broadly rounded. Aperture slightly oblique, elongate-ovate, canal broken below. Columella vertical, bent to left below. Inner lip narrow, pointed below.

Holotype in author's collection.

Height, 22 mm.; diameter, 10 mm. (holotype).

Locality.—Waihao greensands, McCullough's Bridge, Waihao River (Tahuian).

Verconella uttleyi n. sp. (Plate 76, fig. 6.)

This species agrees in shape, protoconch, and apertural detail with *V. spiralis* n. sp. The sculpture is much heavier and the axial ribs more

pronounced, 13 on the body-whorl; 14 main spiral ribs on penultimate whorl; interstices narrower with finer cords.

Holotype in author's collection.

Length, 24 mm.; diameter, 12 mm.

Locality.—" Island sandstone " beds, lower Waihao River (Bortonian).

" Belophos " incertus (Marshall). (Plate 76, fig. 8.)

1919. ***Belophos incertus*** **Marshall,** ***Trans. N.Z. Inst.,*** **vol. 51, p. 229, pl. 15, fig. 3.**

This species is figured from a McCullough's Bridge (Tahuian) specimen to show its close relationship to the three species of " *Verconella* " here described. Dr. Marshall's original figure was from a specimen which had lost the long canal. *Belophos* has a deep anterior notch and this species has none, but, as a revision of the family will probably provide a new generic name for the whole group of these forms, Marshall's classification may remain for the present.

Latirus (Peristernia) neozelanicus (Suter). (Plate 76, figs. 5*a*, 5*b*.)

1917. *Tudicla neozelanica* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 17, pl. 11, figs. 17, 18.

Several fine specimens of *Tudicla neozelanica* Suter were collected by the writer from Waihao Downs and were examined by Dr. Marwick. He considers that the flat spire is like *Tudicla*, but the aperture is more important and is closer to *Peristernia*, a subgenus of *Latirus*, as there is a strong fold at the bottom of the columella. Probably a new generic division is required for this shell.

Family MITRIDAE Adams.

Conomitra inconspicua (Hutton). (Plate 77, figs. 1*a*, 1*b*.)

1885. *Mitra inconspicua* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 326, 1884.

1887. *Mitra inconspicua* Hutton, *Proc. Linn. Soc. N.S.W.* (2), vol. i, p. 212, 1886.

1915. *Mitra inconspicua* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 20, pl. 4. fig. 7.

1924. *Conomitra inconspicua* (Hutton): Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 468, pl. 50, figs. 2*a*, 2*b*.

Dr. Marwick comments: " Hutton gave as localities Mount Harris and Waihao greensands. Suter says the type is from Mount Harris; but I have seen the two specimens in the Canterbury Museum labelled ' holotype ' and ' paratype,' and they are undoubtedly from the greensands. I have not seen this species from an Awamoan horizon."

Localities. — McCullough's Bridge (Tahuian) and Waihao Downs (Bortonian).

Conomitra apicicostata (Suter).

1917. *Vexillum apicicostatum* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 27, pl. 12, fig. 5.

Locality.—McCullough's Bridge, Waihao River (Tahuian).

Vexillum parki n. sp. (Plate 77, fig. 2.)

Shell small, fusiform, turreted. Sculpture of spiral cords, strongest on keel, nearly obsolete near base of body-whorl; spiral cords crossed by axial ribs, well developed on spiral whorls, feebly developed on body-whorl. Spire-whorls with prominent median keel. Sinuous growth-lines ornament

body-whorl. Spire turreted, slightly shorter than aperture. Protoconch worn. Whorls 6, regularly increasing. Suture deep. Aperture oblique, narrow, truncated posteriorly, produced into a short canal in front. Outer lip broken. Columella oblique, with 4 plaits, the anterior being poorly developed.

Holotype in author's collection.

Length, 15 mm.; diameter, 6 cm. (holotype).

Locality.—McCullough's Bridge, Waihao (Tahuian).

This species is related to *V. ligatum* Suter from Wharekuri, and to *V. rutidolomum* Suter from Mount Horrible. It differs from the former in spiral ornament, and from the latter in possessing fewer axial ribs and different shape of whorls.

Family CANCELLARIIDAE Adams.

Uxia ? marshalli n. sp. (Plate 77, figs. 3*a*, 3*b*.)

Shell small, subturriculate, heavily sculptured. Sculpture of heavy axial ribs, 11 on body-whorl. Spiral ornamentation of strong cords separated by much finer threads; the whole surface appears cancellated; 9 main spirals on body-whorl.

Holotype with 4 whorls (broken at apex); paratype with 5 whorls and a worn globular protoconch. Whorls convex. Suture deep. Aperture subtrigonal, with a short open anterior canal. Outer lip varicose, crenate within. Columella with 3 plaits, the anterior being absorbed in the twist of columella.

Holotype and paratype in author's collection.

Length—holotype, 10 mm.; paratype, 12 mm. Diameter—holotype, 5 mm.; paratype, 6 mm.

Dr. Marwick makes the following comments: "Cossmann says that the canal of *Uxia* has a notch '*assez profonde*,' but this is not borne out by his figure of the genotype. *Uxia* has a posterior plait on the parietal wall just as this species has."

If this determination is found to be valid, this is the first record of *Uxia* from the Tertiary beds of New Zealand.

Locality.—Waihao greensands, McCullough's Bridge, Waihao River (Tahuian).

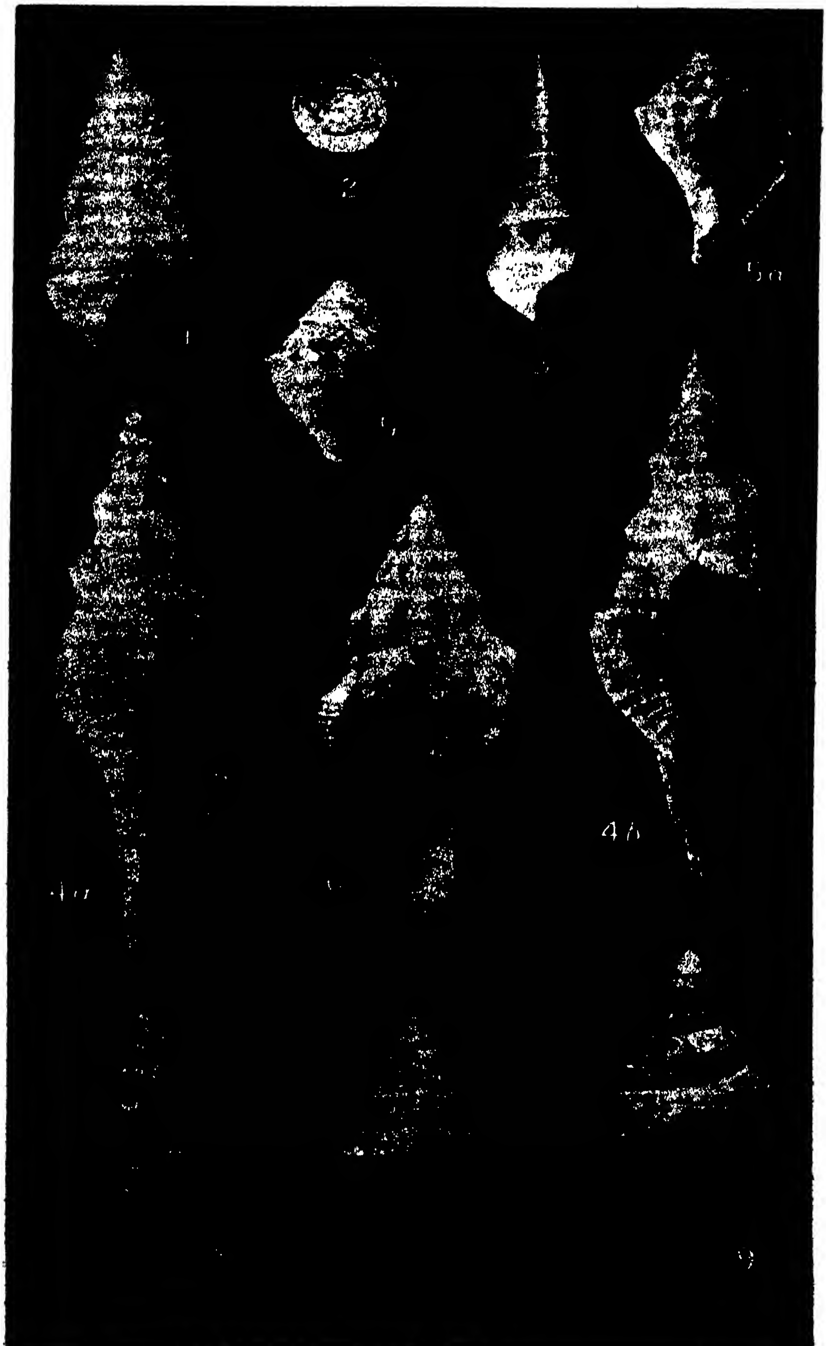
Family OLIVIDAE d'Orbigny.

Ancilla morgani n. sp. (Plate 77, figs. 4*a*, 4*b*.)

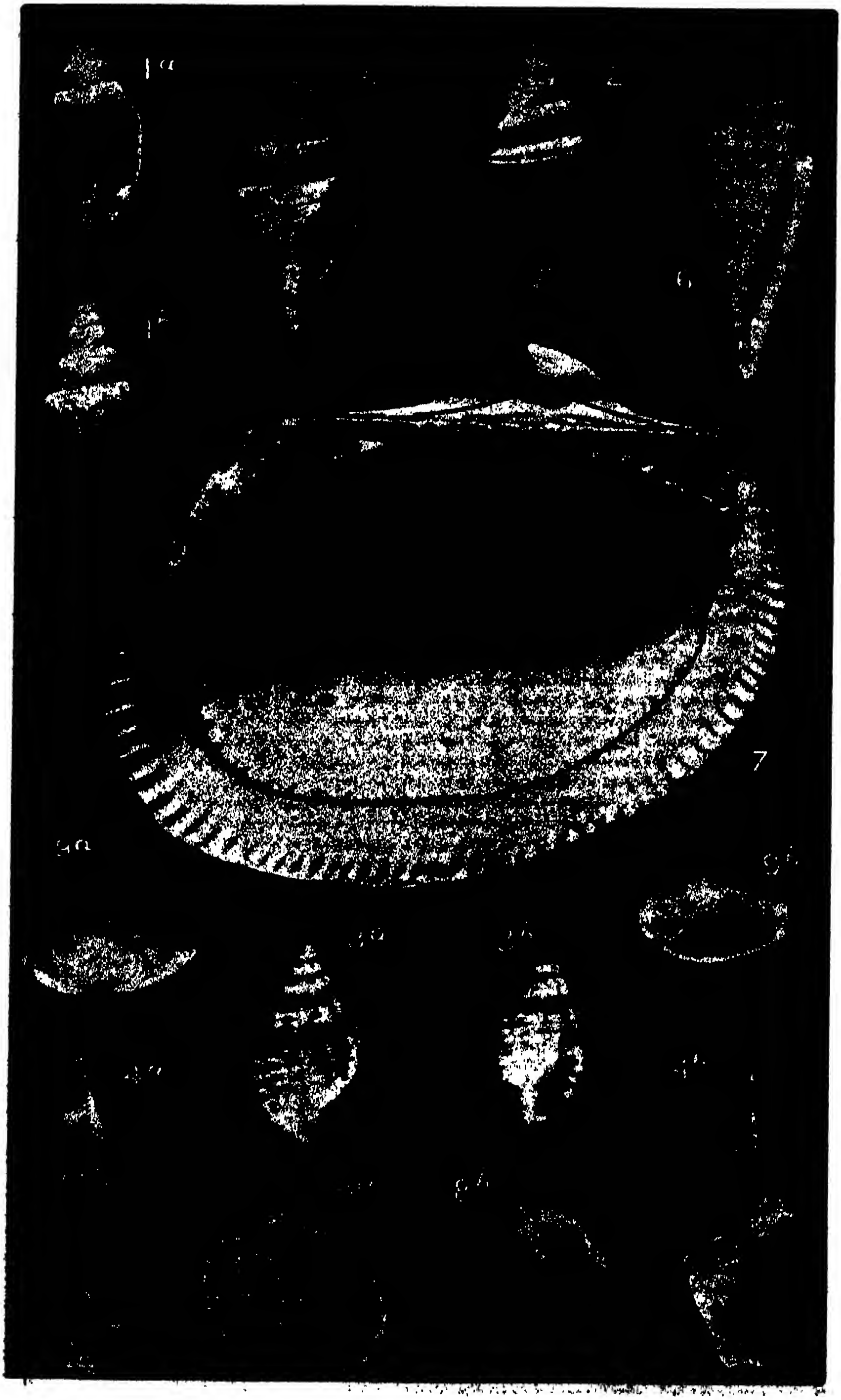
Sculpture consists of moderately fine lamellose growth-lines on the smooth part and on the sunken lower band, those of the latter band being inclined

DESCRIPTION OF PLATE 76.

FIG. 1.—*Perissoptera* (*Hemichenopus ?*) *thomsoni* n. sp. Waihao Downs. × 2.
FIG. 2.—*Architectonica marwicki* n. sp.: holotype. McCullough's Bridge. 2.
FIG. 3.—*Eulima waihaoensis* n. sp.: holotype. McCullough's Bridge. × 2.
FIG. 4*a*.—*Fusinus bensoni* n. sp.: holotype. Waihao Downs. × 2.
FIG. 4*b*.—*Fusinus bensoni* n. sp.: paratype. Waihao Downs. × 2.
FIGS. 5*a*, 5*b*.—*Latirus* (*Peristernia*) *neozelanicus* (Suter). Waihao Downs. × 1·5.
FIG. 6.—*Verconella uttleyi* n. sp.: holotype. "Island sandstone." × 2·5.
FIG. 7.—*Verconella formosa* n. sp.: holotype. McCullough's Bridge. × 2·5.
FIG. 8.—*Belophos incertus* Marshall. McCullough's Bridge. × 2·5.
FIG. 9.—*Verconella spiralis* n. sp.: holotype. McCullough's Bridge. × 2·5.



Face p. 342.]



at a slight angle to those above; these are crossed by exceedingly fine spiral striae; above the smooth band the spire is covered with callus of pearly lustre. Spire equal in height to aperture, acuminate, outlines straight; angle of spire less than 50°. Protoconch small, concealed. Whorls 4; spire-whorls straight; body-whorl convex, restricted at base. Smooth band slightly less than one-third height of shell. Width of sunken band one-quarter that of smooth band and separated from it by a groove. Aperture half total height; almost rectangular in outline, with a constriction above, deeply notched at base. Outer lip only slightly convex. Columella and inner lip as for *A. waikopiroensis*.

Holotype and numerous paratypes in author's collection.

Height, 17 mm.; diameter, 7 mm. Aperture—height, 8 mm.; breadth, 3 mm. (holotype.)

Locality.—Waihao greensands, McCullough's Bridge, Waihao River, South Canterbury (Tahuian). Also from the Bortonian beds of Waihao Downs.

This species is nearest to *A. waikopiroensis* (Suter)—in fact, the shell from Waihao was called *A. waikopiroensis* by Suter (*N.Z. Geol. Surv. Pal. Bull. 5*, p. 42). It differs from *A. waikopiroensis* (Suter) in the following points: The new species is much narrower in proportion to the width; the base is much more constricted; the aperture is distinctly less oval and the outer lip less convex; the chief character of distinction is the relatively very broad depressed band below the smooth area.

Family TURRIDAE H. and A. Adams.

Gemmula bimarginata (Suter).

1917. *Turris bimarginatus* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 44, pl. 5, fig. 13.

Locality.—McCullough's Bridge (Tahuian).

Gemmula complicata (Suter).

1917. *Turris complicatus* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 45, pl. 5, fig. 14.

Locality.—McCullough's Bridge (Tahuian).

Gemmula duplex (Suter).

1917. *Turris duplex* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 45, pl. 5, fig. 15.

Locality.—McCullough's Bridge (Tahuian).

DESCRIPTION OF PLATE 77.

FIGS. 1*a*, 1*b*.—*Conomitra inconspicua* (Hutton): topotypes. McCullough's Bridge. × 2·3.
FIG. 2.—*Vexillum parki* n. sp.: holotype. McCullough's Bridge. × 2.
FIG. 3*a*.—*Uxia ? marshalli* n. sp.: holotype. McCullough's Bridge. × 3.
FIG. 3*b*.—*Uxia ? marshalli* n. sp.: paratype. McCullough's Bridge. × 3.
FIG. 4*a*.—*Ancilla morgani* n. sp.: holotype. McCullough's Bridge. × 2·5.
FIG. 4*b*.—*Ancilla morgani* n. sp.: paratype. McCullough's Bridge. × 2·5.
FIG. 5.—*Parasyrinx finlayi* n. sp.: holotype. McCullough's Bridge. × 2·3.
FIG. 6.—*Conus* (*Conospira*) *tahuensis* n. sp.: holotype. McCullough's Bridge. × 2·5.
FIG. 7.—*Cucullaea waihaoensis* n. sp.: holotype. Waihao Downs. × 1·3.
FIGS. 8*a*, 8*b*.—*Limopsis waihaoensis* n. sp.: holotype. McCullough's Bridge. × 3·5.
FIG. 9*a*.—*Nuculana belluloides* n. sp.: holotype. McCullough's Bridge. × 2·5.
FIG. 9*b*.—*Nuculana belluloides* n. sp.: paratype. McCullough's Bridge. × 2·5.

Parasyrinx finlayi n. sp. (Plate 77, fig. 5.)

Shell small, elongate-fusiform, very strongly keeled. Sculpture: The prominent keel is high on body-whorl but at about middle of succeeding whorls; in both cases its edges are serrated. Body-whorl spirally lirate below keel. Upper three spirals wide apart, middle one strongest. Towards base spirals are closer together and more numerous; they are broken into nodules by radial growth-lines. Except for margined suture, spire-whorls show only very faint spirals. Sinus above keel, and is deep, broad, and rounded. Spire produced, slightly longer than aperture. Protoconch of two smooth and convex whorls. Whorls 5, regularly increasing, concave above and below suture, base contracted below. Suture margined above by a strong cord. Aperture long, ovate, contracted below into a long open canal which is not complete. Outer lip sharp and thin, with well-developed sinus. Columella straight. Inner lip narrow as thin enamel.

Holotype in author's collection; paratype in Dominion Museum, collected by Dr. J. A. Thomson, 1917.

Length, 17 mm.; diameter, 7 mm. (holotype).

Locality.—Waihao greensands, McCullough's Bridge, Waihao (Tahuian).

This is "*Ancistrosyrinx* n. sp." of Suter (*N.Z. Geol. Surv. Pal. Bull. 8*, p. 66, 1921).

Family CONIDAE Adams.

Conus (Conospira) tahuensis n. sp. (Plate 77, fig. 6.)

Shell fusiform. Sculpture consists of growth-lines showing a rounded sinus above keel. First whorl with traces of axial nodules; later whorls show traces of spiral ribs. Spire elevated, staged. Whorls 5; keel high in body-whorl but below centre on succeeding whorls. Protoconch of 2 whorls, proboscidiform. Suture impressed, margined below. Aperture long, oblique, slit-like, with an open canal.

Holotype in author's collection.

Length, 20 mm.; diameter, 6 mm. (holotype).

Locality.—McCullough's Bridge, Waihao River (Tahuian).

Family LEDIDAE Adams.

Nuculana solenelloides (Marshall).

1919. *Sarepta solenelloides* Marshall, *Trans. N.Z. Inst.*, vol. 51, p. 233, pl. 15, figs. 4, 5, 6.

This Hampden species was recorded from McCullough's Bridge by Dr. Marshall (1923), and was collected by Dr. Thomson in 1917. According to Mr. Finlay, it would be more suitably located in the genus *Nuculana*.

Nuculana belluloides n. sp. (Plate 77, figs. 9*a*, 9*b*.)

Shell small, ovate, equivalve, inequilateral. Beaks approximate, slightly behind anterior third. Anterior end shorter, rounded; posterior margin elongated into a sharp beak, dorsal surface concave; ventral margin gently rounded. Lunule indistinct, escutcheon distinct, lanceolate bounded by a rounded ridge, obliquely longitudinally striate. Sculpture of numerous fine concentric folds. Interior (from paratype) shining, smooth; teeth small, numerous; resilium small, triangular; adductor-scars shallow; pallial line simple; margin simple.

Holotype and paratypes in author's collection.

Length (holotype, two valves), 10 mm.; breadth, 5 mm.; thickness, 3 mm.

Locality.—McCullough's Bridge (Tahuian).

Family ARCIDAE Dall.

Cucullaea waihaoensis n. sp. (Plate 77, fig. 7.)

The description is taken from the holotype—a beautifully preserved left valve.

Shell large, thick, somewhat variable in outline, subquadrangular. Anterior margin slightly convex, rounded; posterior dorsal margin almost straight, very slightly rounded. Posterior ventral margin well rounded. Posterior much wider than anterior. Interior porcellaneous, showing faint radial striations inside (*i.e.*, dorsally to) pallial line, which is simple and well defined. Anterior adductor triangular; posterior adductor larger, quadrangular, raised. Margin with many narrow pointed crenulations. Hinge-line straight; hinge-plate solid, lower margin concave. Central taxodont teeth small, numerous; lateral teeth well marked, varying from 4 to 6 in number, 3 or 4 well developed. Lateral teeth grooved or pitted vertically. Area triangular, with 6 incised ligament-pits running obliquely from umbo, which is uncurved and directed anteriorly. Area ornamented with striae parallel to hinge-line. Ornamented with radial ribs crossed by much finer concentric striae, giving a reticulate pattern.

Holotype, from Waihao Downs (Bortonian), in the writer's collection.

Measurements of holotype (left valve): Length, 6·8 cm.; breadth, 5·8 cm.; thickness, 2·5 cm.

Occurs also in the Tahuian beds at McCullough's Bridge.

Relations.—*C. waihaoensis* differs markedly from the Palaeocene species from Wangaloa and Boulder Hill. It is also distinct from the common Awamoan shell *C. attenuata* Hutton. It differs from the latter in the smaller size, and especially in the marked difference in number and position of the ligament-grooves.

Family LIMOPSIDAE Dall.

Dr. Marshall (1923) records two species—*Limopsis aurita* (Brocchi) and *Limopsis zitteli* Ihering.

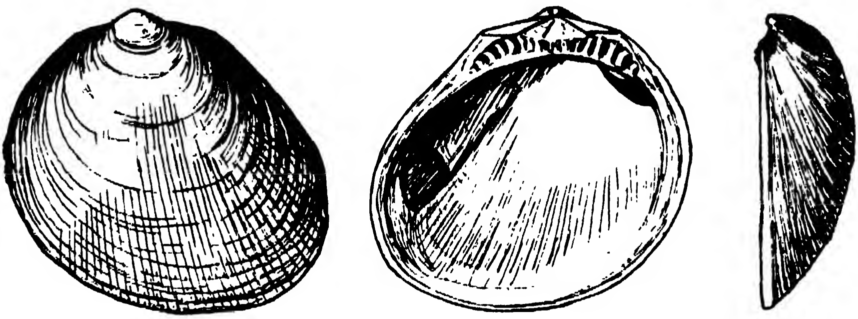
Mr. Finlay tells me that *L. aurita* is not a New Zealand shell, and that the shell so called should be referred to as *L. zelandica* Hutton. Further, both *L. zelandica* and *L. zitteli* are known to be restricted to "Miocene" horizons. *L. zelandica* is characteristic of the Pukeuri beds, while *L. zitteli* is found typically at Target Gully, Oamaru.

The Waihao specimens fall into two species, which Mr. Finlay has kindly described for me.

Limopsis campa n. sp.

Young shell irregularly orbicular, adult shell obliquely ovate, elongation occurring ventrally and posteriorly. Ligament area not long, of medium height; pit large, inequilateral; furrow prominent. Beaks very low. Concentric ornament of fine growth-lines. Radial ornament of numerous not quite linear grooves over the whole surface. Posterior area a little frilled, with irregular grooves.

One of the chief characteristics of this species is the narrowness of the marginal bevelling; the usual broad platform is so limited that it appears like a blunt edge.



[J. Marwick, del.

Limopsis campa n. sp. Holotype.

Shell of moderate size; type, 23·5 mm. in height, 25 mm. in length.

Holotype in Mr. Finlay's collection. The writer has numerous metatypes.

Locality.—Waihao greensands, Waihao Downs (Bortonian).

Limopsis waihaoensis n. sp. (Plate 77, figs. 8*a*, 8*b*.)

Young shell irregularly orbicular, slightly more quadrate than in *L. campa.* Adult shell very small for the group, of somewhat similar shape and elongation to *L. campa*, but rather more oblique, thinner, and more inflated. The tumidity is, in fact, rather pronounced relative to the size of the shell. Ligament area as in *L. campa*, but the pit is small and either equilateral or compressed. Furrow rather weak. Beaks very low. Concentric ornament of uneven grooves and furrows, forming low ridges at the sides; more pronounced than in *L. campa.* Radial ornament much finer and closer than in *L. campa*, almost obsolete over most of the surface but distinct; fine and numerous threads are present on the posterior area, raised into frills on intersecting the concentric furrows. As in *L. campa*, the marginal bevelling is very narrow—even narrower than in that species.

Height, 6·5 mm.; length, 7·5 mm.

Holotype in Mr. Finlay's collection.

Locality. — Waihao greensands, McCullough's Bridge, Waihao River (Tahuian).

Geology of Fossil Localities near Waipukurau, Hawke's Bay.

By J. ALLAN THOMSON, D.Sc., F.N.Z.Inst., Hutton Medallist, Director of the Dominion Museum.

[*Read before the Wellington Philosophical Society, 8th October, 1924: received by Editor, 31st December, 1924: issued separately, 31st March, 1926.*]

As a fossil locality Waipukurau is known chiefly for the late Tertiary Bryozoa collected by A. Hamilton and described by A. W. Waters in 1887. The neighbouring township of Waipawa is known chiefly for the record by A. McKay (1879) of an ammonite in the "chalk marls" of the Waipawa Gorge, which was supposed to prove the Cretaceous age of the Amuri limestone. In 1919 Mr. E. K. Lomas read a paper (not published) to the Geological Section of the Wellington Philosophical Society, entitled "Some Geological Observations in the Hatuma District," and exhibited collections of fossils, mainly late Tertiary brachiopods, from numerous localities near Waipukurau. In 1921-22, during a residence of over a year at the Pukeora Sanatorium, I was able to make extensive collections of fossils from its immediate neighbourhood. During the same period Dr. G. Uttley and Dr. J. Marwick collected in the late Tertiary beds farther north, and together we made two excursions in the country around Waipukurau. Dr. Marwick (1924) has already published an account of the fossil molluscs collected by him, only one species, however, from the Waipukurau area being included, and I have to thank him for the identifications published in this paper, including those collected by Dr. Uttley and himself. In point of number the Bryozoa easily come first amongst the fossils I collected, being numbered in many hundreds of specimens, and Brachiopoda come next, with over a hundred. The Bryozoa have been handed to Dr. G. Uttley for examination in connection with the general revision, which he has in hand, of the Tertiary faunas of that group. In the meantime, until lists of species are prepared, it seems desirable to give an account of the fossil localities in order to facilitate subsequent reference, and that is the primary purpose of this paper. The area closely studied and explored on foot lies within a circle of a mile radius from Pukeora. Occasional motor and train journeys, however, enable a general outline of the broad structural and stratigraphical relationships of a much wider district to be attempted, and this may be of service in directing the attention of geologists to a part of New Zealand which will amply repay more detailed investigations.

The only geologists who have recorded their observations in the area are A. McKay (1877, 1879, and 1887) and H. Hill (1887, 1891, 1893, and 1909), and in neither case are the writers particularly concerned with the area under discussion, but make brief mentions of the more important beds and geological features in papers covering a much wider area, exception being made of Hill's paper (1893) on the structure of the gravels of the Ruataniwha Plains. McKay's papers were written early in his career, when writing did not as yet come easy to him, and before he had developed fully the ideas on structure which his explorations in the Clarence Valley crystallized; nevertheless, as in so many other districts in New Zealand, he laid a true foundation, and has proved to be correct in all but minor

points in stratigraphy and structure, while in regard to physiography it is of interest to record that in his paper of 1877 he gave a clear description of a stripped deposition plane or "fossil peneplain" on the greywacke rocks north-west of our area. Hill, in his numerous papers on the geology of Hawke's Bay, has given many valuable details in regard to the Tertiary rocks, but in our area he has not added much to McKay's account; his most valuable contributions relate to the artesian systems in the various alluvial plains of Hawke's Bay, a field in which he is the only authority, but with which we are here not concerned. His later paper (1909), on "The Great Wairarapa: A Lost River," is entirely discounted by recent physiographical studies on the origin of the surface features throughout New Zealand.

The rocks which, in my former papers on the Clarence Valley and the Waipara and Weka Pass districts, I have grouped together as broadly accordant series under the name of Notocene, in southern Hawke's Bay form two strongly discordant series, for which I propose the local names of the Waipukurau series for the Upper Tertiary members, and the Waipawa series for the Middle or Upper Cretaceous members. These correlate with the upper and lower parts of the Notocene of the South Island, the middle parts being missing. With this qualification it is possible, as in other areas, to divide the rocks into Prenotocene, Notocene, and Notopleistocene.

Prenotocene Rocks.

Prenotocene greywackes, argillites, and the usual associated rocks form the Ruahine Range and its northern continuations lying to the west of Hawke's Bay, and presumably form the floor of the Notocene rocks to the east. Within this area there is no intrinsic evidence as to their age; doubtless, as in other parts of New Zealand, they are mainly Triassic, but may include strata from Permian to Lower Cretaceous. McKay has divided them, in the area between Masterton and Napier, into an older Rimutaka series and a younger Wairoa series; but his main criterion appears to be the state of weathering of the included sandstones, which in turn is dependent on their porosity and their late physiographical history, and is not a valid criterion for stratigraphical separation without regard to these other factors. The greywacke series, according to McKay, project through the Notocene cover to the east in only one place between Woodville and Napier—viz., to the south of Takapau, as shown on his map (1877). I have, however, in 1914 recorded an outcrop a little to the north of Woodville, and there are probably others not yet discovered. In the case alike of the main ranges to the west and of these two inliers, contacts only with the younger Tertiary rocks are displayed, but no contacts with the older Waipawa series, and unless further inliers are found within the area occupied by the latter series its relationship to the greywacke series must remain a matter of inference. The evidence is clear enough that the Ruahine and northern greywacke ranges owe their present elevation to post-Notocene earth-movements (the Kaikoura orogeny). Not only are rocks of the Waipukurau series deeply involved with the greywackes to the north-west of the Ruataniwha Plains, but a little farther north the mountains are capped with beds of limestone, which thus connect the Upper Tertiary rocks of Hawke's Bay with those of the Taihape district to the west of the greywacke mountains. Between the Waipukurau series and the greywackes, however, there is a profound unconformity, with close folding and peneplanation of the greywackes before the Upper Tertiary sea transgressed

over them; judging from the history of other parts of New Zealand, the probabilities are that the close folding antedated the deposition of the rocks of the Waipawa series; but, as stated above, this must remain an inference until actual contacts are discovered between the two series.

WAIPAWA SERIES.

The attitude of the rocks of the Waipawa series proves that an orogenic movement of considerable magnitude took place within the Notocene. As mapped by McKay, under the name of "Inoceramus beds," these rocks extend south-east from about Otane in a broad band to the sea-coast from Black Head, north of Porangahau, to some miles south of Cape Turnagain. They form, according to him, an undulating country of low hills, exhibiting a remarkable uniformity in rock characters—viz., chalk-marls with black bituminous marls full of scales of mica at one or two points. For the most part they dip at high angles to the east, and are shown on his sections as fairly closely folded, in contrast to the gentle dips of the rocks of the Waipukurau series which overlie them on the west.

McKay's description of these rocks as chalk-marls is quite inaccurate, and was due partly to his inexperience at this time and partly to his expectation that they must correlate with the Amuri limestone. The rocks in the Waipawa Gorge, to which he first gave the name of chalk-marls, are light-coloured, fine-grained, almost flinty, siliceous mudstones exactly similar to flinty mudstones in the Clarentian series in the Ward, Woodside, and Kekerangu districts of Marlborough, and bearing rare elongate brownish calcareous concretions similar to concretions in the Clarentian; somewhat similar flinty mudstones are also locally developed in the Piripauan of the Weka Creek, Waipara district, but without concretions. I have tested these rocks in the Ward district with acid for lime, with entirely negative results. As described by McKay, these rocks contain rather poorly preserved Foraminifera and fish-scales, and dip steeply to the east or south-east. The supposed ammonite which he obtained from them was some years ago examined by Mr. H. Wood, of Cambridge, who reported that it was a crushed Nautiloid. Farther down the Waipawa River, on the north side of the road-bridge, there is a cutting exposing the rocks which he described as "black bituminous marls full of scales of mica." The rocks, however, are not black, but dark purple, and they are covered on joint-planes and outcrops with a yellow sulphur efflorescence; they agree exactly in appearance with the sulphur mudstones found in the Clarentian of Kekerangu and the Piripauan of the Waipara River, but, unlike them, contain recognizable Foraminifera. The peculiar lithology of these two types of rock, known in New Zealand only in the Piripauan and Clarentian, is evidently the result of special conditions which prevailed during those stages, and gives good grounds, in anticipation of examination of the fossils, for correlating these beds with the Cretaceous members of the Notocene—viz., with the Piripauan or the Clarentian.

In the Tukituki River below Waipukurau the rocks of the Waipawa series are dark mudstones of more ordinary nature, but harder than is usual amongst Tertiary mudstones in New Zealand. Similar dark mudstones outcrop at many points on the road to Porangahau, and there is a large district here awaiting exploration. Near Porangahau there is a road-metal quarry in thin-bedded, pale-green, moderately coarse glauconitic sandstone and finer-grained grey-green streaky and flinty rocks, some of which greatly resemble some bands of the Amuri limestone of Marlborough. All are

steeply inclined. Beyond these, the Mangamaire Valley to the south of Porangahau is a broadly open valley composed of soft mudstones and weak sandstones, more comparable in induration to Tertiary than to Cretaceous rocks. The ridges bounding the valley are hard glauconitic sandstones, alternating with white flinty and lilac-coloured mudstones of more usual Cretaceous aspect. It appears possible that the soft mudstones are of Tertiary age, lying above the limestone, and that the Waipawa series ranges up to the Lower Tertiary, but a critical examination of the Foraminifera collected from them will probably resolve the doubt. No doubt molluscan and other larger fossils will be obtained from the mudstones of the Waipawa series by a more extended search than I was able to make. Meanwhile small collections of Foraminifera are available in the Dominion Museum for any specialist who cares to undertake their examination.

Waipukurau Series.

The rocks of the Waipukurau series, as developed near Pukeora, may be subdivided as follows :—

	Feet.
Maharakeke clays	100+
Pukeora oyster-beds	80 90
Makaretu clays	60–100
Te Aute limestone	200–300
Tukituki sands	200

These names for the subdivisions of the Waipukurau series have been given for convenience of description and reference, but may prove to have a purely local value, and are not intended to replace earlier names for the same rocks in other parts of Hawke's Bay. As to correlations, the Te Aute limestone has usually been correlated with the Waitotaran. The beds overlying the limestone are apparently the equivalents of the Petane clays, which Marwick (1924) correlates with the Nukumaruian. The Tukituki sands are presumably older than Waitotaran, but the species of *Neothyris* which they contain forbid correlation with the Awamoan. A critical examination of the brachiopods may assist in defining the correlations more exactly.

The Te Aute limestone forms a bold escarpment 300-400 ft. above the low-lying ground occupied by the Waipawa series to the east, and dips at about 10° to the west. It is, according to McKay, a continuation of the limestone of the Puketoi Range north-east of Woodville, and from the Waipukurau area trends north and then north-east to Cape Kidnappers. With the associated rocks it forms a line of hills, rising over 1,000 ft. in height, which separate the extensive Ruataniwha Plains on the west from a low-lying strip on the east on which lie Hatuma and Waipukurau. The Ruataniwha Plains form a large intermont basin comparable to those in Canterbury and Otago. Like the Culverden basin, it possesses two distinct drainage outlets—viz., the gorges of the Waipawa and Tukituki Rivers—and has a third breach in the eastern wall not occupied by a stream but used by the railway between Takapau and Hatuma. The plain is composed of river alluvium, brought down from the greywacke ranges to the west by the tributaries of the Tukituki and the Waipawa Rivers, and spread out to form a continuous plain between these rivers ; its height above sea-level at the Tukituki Gorge is approximately 400 ft. The courses of these rivers through the eastern limestone wall must thus be antecedent to the synclinal deformation which caused the basin. Its western margin,

which I have not had an opportunity of examining, and which McKay did not examine in detail, appears to be composed also of Upper Tertiary rocks, dipping to the east, together with older gravels. Probably the eastern depression on which Hatuma and Waipukurau lie is equally a structural basin, but it is probable that faulting has had more influence in its development than simple folding.

Of the rocks of the Waipukurau series McKay originally recognized in this neighbourhood only the Te Aute limestones and overlying clays. He described the Te Aute limestone as lying hard upon the Waipawa series south of the Waipawa River, recognizing beds conformably under the limestone only farther north, where they are described as blue sandy beds. I did not see the actual junction in the Waipawa Gorge, but the relative positions of the limestone escarpment, dipping gently to the west, above, and the flinty mudstones of the Waipawa series dipping steeply to the east in the road-cuttings below, leave no doubt of the strongly unconformable relationship of the two series, but at the same time admit the possibility of 100 ft. or more of weak beds below the limestone. These underlying beds are exposed near the Tukituki limestone gorge in road-cuttings on the Main South Road, and also on the Onga Road flanking the base of the hill towards the gorge. They are for the most part grey sands containing occasional brachiopods (*Neothyris*) and rare pelecypods—viz., *Anomia undata* Hutt., *Chlamys radiatus* (Hutt.), and *Ostrea angasi* Sow.; on the Onga Road the lowest rocks seen contain thin clay bands with fragmentary plant-remains and hard impure sandstone bands. Near the base of the limestone on the main road is an outcrop of blue clayey sandstone with oysters and numerous broken brachiopods, mostly *Tegulorhynchia nigricans*, but this may possibly be a down-slipped mass of the Makaretu clays which overlie the limestone. To the beds underlying the limestone I have given the name of the "Tukituki sands." I estimate their thickness at about 200 ft. For the most part they are obscured by extensive talus deposits of soft limestone coming from the escarpment above, deposits which should be of value for agricultural purposes, as they are considerable in extent, need little crushing, and are easily accessible to the road and railway. They would also be excellent material for fowl-grit.

McKay (1887) has described a considerably greater thickness of beds conformably underlying the Te Aute limestone in a section a few miles to the south-west from the Takapau Railway-station east to the inlier of greywacke rocks forming Woolshed Hill ("Johnston's woolshed"). The beds are brown and grey sands, the latter with bands of brown and greenish soft sandstone, yielding fossils which he identified as *Dentalium nanum*, *D. laeve*, and *Limopsis aurita*. These rest on a bed of white clay. It seems probable that a lower horizon than the Tukituki sands occurs here, pointing to an overlap.

In 1879 McKay found clays with fossils on the eastern slope of Mount Vernon, near Waipukurau, below the limestone escarpment, and correlated them with the clays overlying the limestone; in consequence he concluded that a marked unconformity must exist between the limestone and overlying clays. In 1887 he abandoned this view after examination of the Takapau section, and concluded that the clays on Mount Vernon underlay the limestone; doubtless they are a facies of the Tukituki sands.

The Te Aute limestone, as exposed along the Main South Road passing Pukeora, is composed of massive beds about 200 ft. thick, passing down into calcareous sands with an increasing amount of quartz downwards, with a second thin bed of limestone at the base. Followed down the dip

to the limestone gorge the massive beds appear to thicken, and there is probably 300 ft. of limestone at this point. Where exposed in cuttings the limestone is rather soft and friable, and is composed largely of worn *Balanus* valves, with Bryozoa next in importance. It is apparently a detrital rock, and shows good current-bedding on the Maharakeke-Hatuma Road; unfortunately, I neglected to observe the direction of the current-bedding, which may be of importance for the mid-Tertiary palaeogeography. There is a small percentage of quartz and glauconite, but the whole rock is very high in lime content. Through the softer parts run joint-planes lined for 6 in. to 2 ft. with very hard limestone of secondary calcification. The boulders outcropping on the hilltops are quite hard, and are partly of this nature and partly residuals of originally harder parts of the limestone left by weathering. Excluding Bryozoa, the limestone is not rich in fossils; whole cirripede valves and calyces are rare, and brachiopods are mostly represented by single valves of *Neothyris* sp., *Terebratella inconspicua*, and *Tegulorhynchia nigricans*; the Mollusca collected have been identified by Dr. Marwick as *Anomia trigonopsis* Hutt., *A.* cf. *undata* Hutt. (juv.), *Chlamys* cf. *convexus* (Q. & G.), *C. radiatus* Hutt. (juv.), *Ostrea angasi* Sow., *O. ingens* Zittel, *Pecten* n. sp., *Pecten* n. sp. aff. *triphooki* Zittel. From the cliff in the Tukituki Gorge opposite Waipukurau Dr. Marwick collected *Anomia undata*, *Chlamys* cf. *convexus* (Q. & G.), *Ostrea angasi*, and *Ostrea ingens*. Probably at other points the limestone will prove more fossiliferous. I have retained the name of "Te Aute limestone," as the escarpment continues unbroken, except for the Tukituki and Waipawa gorges, from Waipukurau to Te Aute.

The beds following the limestone are not exposed in continuous section near Pukeora. On the dip-slope of the limestone below the Sanatorium destructor is a small hillock of sandstone containing a few oysters and casts of other molluscs and fairly numerous finger-shaped and pustulate Bryozoa. This sandstone does not seem to form a persistent horizon. Elsewhere the beds following the limestone form smooth grassy slopes at the foot of the dip-slopes of the limestone, and are evidently weak rocks protected by the overlying harder oyster-bed. They are partially exposed in cuttings on the Onga Road near the bridge over the Makaretu River, and on cliffs on this river between the Onga Road and the Main South Road, as blue clays, to which the name of "Makaretu clays" may appropriately be given. They are at least 60 ft. thick, and may possibly be 100 ft. Besides Bryozoa, brachiopods, and cirripedes, they contain fairly plentiful molluscs, the following being identified by Dr. Marwick from the collections I made: *Anomia undata* Hutt., *Anachis pisaniopsis* (Hutt.), *Alcithoe lutea* Marwick, *Antigona zelandica* (Gray), *Calyptraea alta* (Hutt.), *Chione subsulcata* Suter, *Chlamys radiatus* (Hutt.), *Cominella hamiltoni* (Hutt.), *Crepidula monoxyla* Lesson, *Dentalium* n. sp. cf. *nanum* Hutt., *Lucinida* n. sp., *Modiolus australis* (Gray), *Ostrea angasi* Sow., *Struthiolaria fossa* Marwick, *Turritella vittata* Hutt. var., *Turritella rosea* Q. & G. var., *Trophon ambiguus* Phil., *Venericardia lutea* Hutt., *V. purpurata* Desh.

The highest points on the hills near Pukeora are composed of oyster-beds with a calcareous cement, which follow the Makaretu clays, and to which the name of "Pukeora oyster-beds" may appropriately be given. They are partially exposed in cuttings on the Main South Road, where they are relatively rich in brachiopods, and in a cutting on the Onga Road at the bridge, and in the forementioned cliff on the Makaretu River. It is from these beds that the largest and best-preserved Bryozoa are obtained, especially from the dip-slopes near the hilltops and in the grass below the

outcrops. Molluscs other than oysters are not abundant, but the following have been identified by Dr. Marwick: *Anomia trigonopsis* Hutt., *Cantharidus* n. sp. cf. *sanguineus* (Gray), *Chione subsulcata* Suter, *Diplodonta zelandica* (Gray), *Gaimardia* n. sp., *Lima* (*Limatula*) *bullata* Born, *Myodora striata* (Q. & G.), *Umbonium anguliferum* (Phil.), *Venericardia purpurata* (Desh.).

The beds immediately following the oyster-beds are not well exposed, but appear to be blue sandy clays. They outcrop in a few cuttings on the Main South Road, where Dr. Marwick collected *Baryspira* cf. *australis* (Sow.), *Callanaitis yatei* (Gray), *Dosinia* sp., *Lutraria solida* Hutt., *Ostrea angasi* Sow., *Philobrya trigonopsis* (Hutt.), *Turritella rosea* (Q. & G.), *T. vittata* Hutt., and *Venericardia lutea* Hutt. The higher beds are better exposed along the Maharakeke Road and Stream, from which they take their name. The beds are upwards of 100 ft. thick. To the west they are covered by the alluvial deposits of the Ruataniwha Plains, so that higher Tertiary beds, such as occur near Napier, are not found near Waipukurau.

From these blue clays on the Maharakeke Road (Geol. Surv. loc. 1092) Drs. Uttley and Marwick collected the following species: *Aethocola taitae* Marwick, *Alcithoe gracilis* (Swainson), *Anachis pisaniopsis* (Hutton), *Antigona zelandica* (Gray), *Baryspira waikopiroensis* (Suter), *Barbatia novae-zelandiae* (Smith), *Calyptraea novae-zelandiae* (Lesson), *Chione* cf. *subsulcata* Suter, *Chalmys radiatus* (Hutt.), *Cominella hamiltoni* (Hutton), *Cominella* n. sp., *Corbula zelandica* Q. & G., *Dentalium nanum* Hutton, *Evarne striata* (Hutton), *Hexaplex espinosus* (Hutton), *Lucinida concinna* (Hutton), *Melatoma buchanani* (Hutton), *Melatoma wanganuiensis* (Hutton), *Melatoma* (*Splendrillia*) *laevis* (Hutton), *Murex zelandicus* Q. & G., *Natica australis* Hutton, *Ostrea angasi* Sow., *Ostrea* sp., *Pratulum pulchellum* (Gray), *Seila terebelloides* (Hutton), *Struthiolaria fossa* Marwick, *Tugali* cf. *intermedia* (Reeve), *Turritella rosea* Q. & G., *Turritella* cf. *symmetrica* Hutton, *Turritella vittata* Hutton, *Venericardia lutea* Hutton, *Verconella thomsoni* Marwick, *Xymene* n. sp.

NOTOPLEISTOCENE BEDS.

No special study has been made of the Notopleistocene beds of the district. Besides the alluvial deposits of the Ruataniwha Plains, which have been described by Hill (1893), there is a series of lacustrine beds in the Tukituki Valley, near Patangata, described by McKay in 1879 and 1887, containing lignite-seams, plant-remains, and fresh-water molluscs.

NOTOCENE HISTORY.

Until the correlations of the Waipukurau series and the Waipawa series are more firmly established, and the beds of intervening age which are known to occur in east Wellington and southern Hawke's Bay have been more closely studied in their relations to the two former series, it is premature to attempt to reconstruct the Notocene history of this part of New Zealand. That intervening beds, of presumably Oamaruian age, are present to the north of the Waipawa series appears probable from McKay's and Hill's descriptions of the beds forming the Silver Peaks Range and exposed in the Tukituki River cliffs near Patangata, but no fossils have been found here. Far to the south, Oamaruian beds are known to the east of Masterton —the Taipo beds of early reports. The exact correlation of these, and an exposition of their relationship to the overlying Wanganuian and underlying Cretaceous beds, are great desiderata.

Ongley (1924) has described an inter-Notocene unconformity in the Poverty Bay district between the Awanui series of Cretaceous age and the Ihungia series of late Awamoan age, and concludes that it is the same unconformity as is present at Waipawa: "Evidently, then, there is a regional unconformity above the fine-grained (Amuri) limestone extending the length of the east coast, and it is thought likely that it extends to the South Island." While agreeing with Ongley as to the probable identity of the unconformities in Poverty Bay, Hawke's Bay, and east Wellington, I cannot follow him in all the conclusions he draws. In the first place, neither the Awanui series nor the Waipawa series has been demonstrated to be exclusively Cretaceous—they may contain early Tertiary beds comparable to the Grey Marls of Canterbury and Marlborough. Secondly, the unconformably overlying beds are distinctly older in Poverty Bay than in Waipawa, pointing to considerable overlap; one would like to know the relationship of the Oamaruian beds in the southern part of the North Island before attempting to reconstruct the Notocene history.

The careful examination of the contact between the Amuri limestone and Weka Pass stone made by Marshall, Speight, and Cotton, by Morgan, by Speight and Wild, and by myself has conclusively proved that there is entire conformity of bedding and no extensive orogeny between these two beds, though doubtless an erosion-interval is present: to compare this contact with the violent unconformities present in the North Island between Cretaceous and Upper Tertiary is to compare small things with great. The reasonable interpretation of the facts as known is that the Notocene history of the North and South Island is dissimilar, and that the Notocene grouping of the various Cretaceous and Tertiary series, which is a practical necessity in the South Island, is hardly justified in the east coast of the North Island.

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Intermontane Basins of Canterbury: Part 2.

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator, Canterbury Museum.

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THE following account is intended to be an appendix to the paper on the "Intermontane Basins of Canterbury" (*Trans. N.Z. Inst.*, vol. 47, 1915, pp. 336-54), wherein the author discussed the question of the origin of certain basins in the mountain region of that province, and came to the conclusion that they were formed initially as the result of deformational movements towards the close of the Tertiary era. This contention was subsequently maintained in another paper, entitled "Notes on a Geological Excursion to Lake Tekapo" (*Trans. N.Z. Inst.*, vol. 53, 1921, pp. 37-46), in which a similar origin was attributed to the inland basin known as the Mackenzie Country.

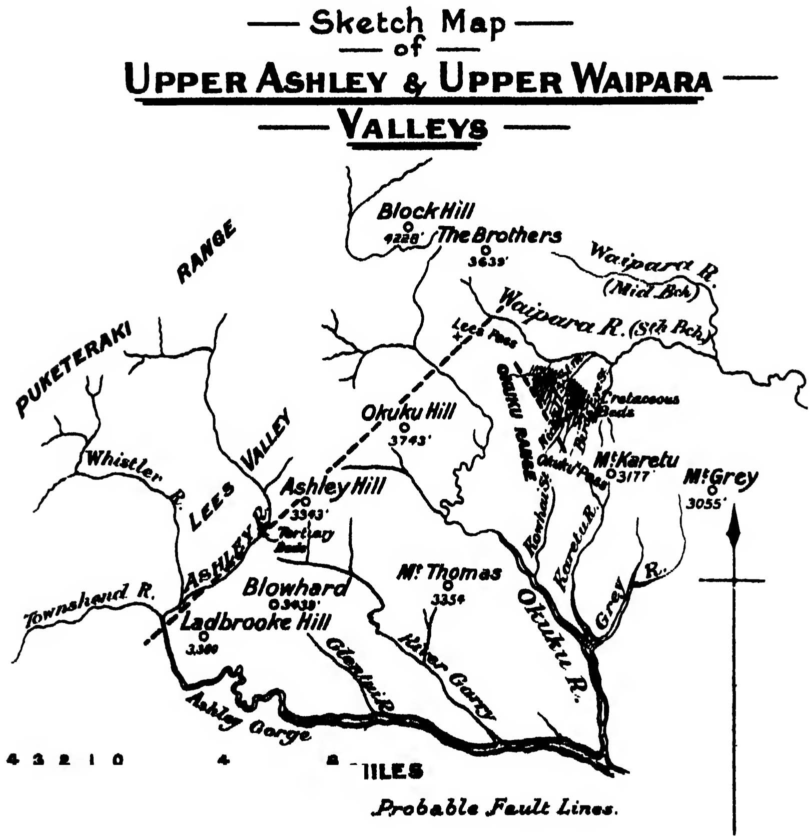
Since writing the last paper I have had additional evidence in support of this conclusion—viz., the discovery of coal on the Balmoral Run, near the head of Irishman Creek, to the east of Lake Pukaki, as well as a similar occurrence of older gravels in which coal is also reported to the west of the Tasman River, the probability of such discoveries being indicated in the last-mentioned article (*loc. cit.*, p. 44). The main portion, however, of the present contribution deals with an entirely different district, situated in north Canterbury.

Recently, by the kind assistance of Mr. J. E. Strachan, of Rangiora, I was enabled to examine an area concerning which there is little information —viz., that at the head of the South Branch of the Waipara River, and the basin of the Upper Ashley, commonly known now as Lees Valley (see map). These two areas occupy two structural basins, probably not entirely independent of each other, which may be called the Karetu (from Mount Karetu) and the Lees Valley basins. It will be best to consider the Karetu basin first. This lies north of Mount Karetu (3,177 ft.), which is immediately west of Mount Grey (see map) and east of the Okuku Range (2,921 ft.), and extends across the South Branch of the Waipara River. The easiest access to it is obtained by means of the road which passes Whiterock over the Okuku Pass, but it may be approached by pack-tracks from Waikari through Heathstock and the McDonald Downs, or by way of the middle gorge of the Waipara. It forms a basin, ringed on every side by greywacke ranges with an average height of between 2,500 ft. and 3,000 ft., except on the north and north-east, where the ring is lower. It is some five miles in length by two to three in breadth. Its most interesting feature is the presence of small discontinuous areas of Cretaceous beds on its floor, which give an important clue to its mode of origin (see map).

These Cretaceous beds are first seen in Birdseye Creek, a tributary of the Waipara rising in the Okuku Range. They occur much better developed in the branch of that creek which flows past the Karetu Hut, on both sides of the road in the next creek to the west—viz., Nicholls Creek—and again farther west still near the road-crossings of the creek near the Mount Laurie

Hut. The thickness of beds exposed is not great as a rule, since the greywacke floor has been uncovered in many places and a mere veneer left, but it is greatest along the base of the Okuku Range on the south-west of the basin, and especially at its southern end, where the remnants of the Cretaceous cover must be several hundred of feet in thickness.

In the Karetu Hut Creek the beds consist of sands, greensands, and clays, with impure lignite, striking north-west and south-east and dipping south-west at low angles. Some of these beds contain very broken shells, but Mr. Strachan was fortunate in coming across the fragment of a belemnite which enables the age of the beds to be stated with reasonable



certainty as being Cretaceous, and they are thus to be correlated with the lower members of the series existing in the classical locality in the middle Waipara and Boby's Creek, and this indicates a much wider extension of these beds towards the west than was formerly believed.

From this locality the beds stretch south-east into Birdseye Creek behind a knob of greywacke, and north-west across the two main branches of Nicholls Creek. In the most easterly branch the beds are developed both above and below the road-crossing. In the latter position they are

sands, greyish-green and brown in colour, concretionary in their lower levels, and associated with beds of sandy clay. The lower members of the sequence are exposed farthest down the creek, where they rest unconformably on greywackes, and their former wider distribution is indicated in the stripped surface which forms the downs extending from the limits of the Cretaceous beds towards the east. The sides of the creek towards the south-west are obscured by scrub and bush, so that the junction with the greywackes in this direction cannot be seen, but it is probably a fault-contact, the line of fault extending north-west along the base of the Okuku Range.

It is probable that the beds once extended from the line of this creek to the north-west, but there are now undoubted exposures of greywackes over large areas, so that the Cretaceous beds form only discontinuous remnants. Where the road crosses the western branch of Nicholls Creek there is a very small remnant of sandy beds bent up into a syncline; but farther west, just at the point where the road leaves a creek to climb out of the basin in the direction of Lees Pass, there is a development of sands and sandy shales with an east-and-west strike and a dip to the north at low angles. Farther up the creek, near the junction with the greywackes, occur lignites, shales, and clays, lower in the sequence, with the same strike but with greatly increased dip. To the south-east of this occurrence there is a fine basaltic dyke, striking north-west and south-east, and standing up as a ridge for several hundred yards, but no contacts with the country rock can be seen on its flanks, even where it crosses gullies. This dyke was not followed beyond the point where it meets the road, but it is possible that it continues some distance farther to the south-east through the scrub-covered country.

Although the Karetu basin is now completely shut off from the neighbouring intermontane area, it was in all probability once connected with it, and the covering Cretaceous and Tertiary beds extended over a wide tract of country to the north and west, where the Lees Valley and its north-easterly extension is now situated.

The Lees Valley intermont is of much greater extent. The area proper is certainly fifteen miles in length, and it may extend to the north-east an additional five to seven miles; the maximum width of the floor is about four miles. It lies behind the range extending from the Okuku River, through Okuku Hill (3,743 ft.), Ashley Hill (3,343 ft.), Blowhard (3,439 ft.)—which might well be called the Ashley Range—to Mount Oxford, while the north-west margin reaches up to the slopes of the Puketeraki Range. The basin is occupied chiefly by the upper waters of the Ashley River, including its tributaries the Townshend and Whistler, but the Okuku flows right across the north-east end and breaks through, by a narrow gorge, the range bounding the basin on the south-east. It is divided from the basins in the Upper Waipara by a northerly extension of the Okuku Range, which sinks to quite a low saddle at Lees Pass. The Ashley collects all the drainage from the rest of the basin, and breaks through the rocky barrier near the south-west corner by means of a steep picturesque gorge. In general the slopes to the north-west of the basin are much more gentle than those to the south-east, a feature of many of the river-valleys and intermontane basins of Canterbury. It thus forms an exact counterpart of the High Peak Valley drained by the Selwyn, except that the latter breaks through at the north-east end and not at the south-west end of the basin; in fact, one could quite imagine, if standing in one of these basins,

that he was in the other, so close is the resemblance in their general features.

Although the general form of the area suggests a tectonic origin for it, with a great fault bounding it on the south-east side and extending along the inner base of what I have called the Ashley Range, there is, fortunately, positive evidence of faulting along this line furnished by the circumstances of a small remnant of Tertiaries in the bed of the Ashley River, near the point where it impinges against this range after its course across the basin from the slopes of the Puketeraki Range. My attention was drawn to this by Mr. W. B. Starky, who sent in to the Canterbury Museum a sample of coal from Lees Valley, and this suggested the possibility of a supply of fuel in a district where wood was scarce. I examined the spot very carefully in company with Mr. Strachan. The exposure is of somewhat limited extent, and has to be approached by wading the river; fortunately this was low at the time of our visit, so we saw all that was likely to be visible at any time.

The beds containing the coal outcrop on the southern bank of the river, the total length exposed on the steep bank being about 100 yards, but they are not clearly visible throughout even that small length. On the spot farthest up-stream where the beds are exposed the following sequence occurs :—

1. Yellowish sands, with fragments of Bryozoa.
2. Greenish sands, weathering brown.
3. Whitish sands.
4. Greenish glauconitic sands.
5. Whitish sands, slightly glauconitic.
6. Carbonaceous grit with quartz-grains.

The beds are capped unconformably with Recent river-gravels. The strike is north-east and south-west, and the dip south-east at an angle of 30°. The total thickness of the exposure is about 50 ft. Some parts show slickensided surfaces.

Down-stream the sequence is obscured, but a little farther on it is again clear but at a slightly higher horizon. At water-level there is a grit, 20 ft. thick, containing quartz pebbles with fragments of bryozoans, echinoid spines and plates, crinoid stems, molluscs, and corals (?), very calcareous in composition, and containing lenses and nests of bright shining coal, crushed and powdery in texture. This is succeeded by 1 ft. of black carbonaceous shale, then by 4 ft. of white sands, and then by 2 ft. of carbonaceous shale (brown coal), and the visible sequence is closed by yellow clay on the line of a thrust-plane, the whole thickness seen being about 30 ft. It is capped by river-gravels, as in the case of the exposure up-stream. The beds strike north-east and south-west, and dip south-east 30°. The grit just referred to is frequently dark in colour, well bedded, with some pieces of coal, looking like stems carbonized in position and not parts of a regular seam. It contains as well numerous rosettes of gypsum crystals. Under the microscope it appears to be composed chiefly of bryozoan fragments.

Just above this occurrence there is a slickensided surface of decomposed black shaly greywacke in contact with whitish sand. About a chain farther down-stream is another exposure of coarse yellowish-white sand, stained brown in places with oxide of iron, derived probably from pyritous matter.

The obvious presence of reversed faulting at this point is very important in its bearing on the origin of the whole valley, and confirms the conclusion

arrived at by inference from physiographic characters. It is possible that there may be evidences of faulting in other places along the northern foot of the Ashley Range, but we could not see any. The fragments of coal have probably been derived from a lower level and brought up by fault-movements, and it is possible, but not probable, that a fair amount exists in position beneath the water-level, and perhaps in other parts of the plain to the north-west, but the exposures of greywacke on mounds penetrating the gravel which covers the floor of the plains, such as that on which the Duckworth Homestead is placed, do not encourage the hope that a payable field exists. If any area does occur it will be beneath water-level, and of limited extent. The cover of Recent gravels prevents a definite answer being given on this point. There may, however, be an area containing coal in the flat on the lower slopes of Blowhard behind Mr. Starky's house.

There is thus little doubt that the basin owes its origin to tectonic movements in which faulting played a part. This area of deformation extends in all probability across the middle course of the Okuku and the uppermost reaches of the three branches of the Waipara towards the Waikari–Hurunui intermont. A most interesting feature of the problem of origin is that connected with the date of the deformation and the relationship of the courses of the Ashley and the Okuku to it. Both rivers present the same anomaly: they rise in the main ridge or the flanking ridges of the Puketeraki Range, flow across the widely opened Lees Valley nearly at right angles to its trend, and then cut through the Ashley Range by means of deep narrow gorges in making their way out on to the plains. What is the reason for this anomaly? That which comes most readily to mind is that the rivers were there before the Ashley Range was formed: they are thus antecedent rivers, and if they were consequent on the surface as it emerged from the sea at the close of the Tertiary era they might be called ante-consequent streams. The presence of the remnant of marine Tertiary beds in the Lees Valley suggests that the sea extended widely over the area in Tertiary times, and when it emerged the rivers such as the Okuku were established on its surface as consequents, and that then deformation took place and the land occupied by the Lees Valley sank, or the Ashley Range was raised, and that in spite of this movement the rivers were able to cut down their beds and maintain their positions. Such a history could not develop without subordinate changes, and it is likely that the Ashley is, after all, formed by the union of other streams which had independent existence as consequents. The gaps in the Ashley Range at the head of the Garry and Glentui may well have marked the initial course of such streams as the Upper Ashley and Whistler, which, together with the Townshend, were absorbed in the main stream following the line of the Townshend over a gap in the ridge just east of Mount Oxford, thus creating the present Ashley Gorge.

There is another solution of the problem. It is quite possible that the original Ashley drained towards Waikari through the low country at the head of the three branches of the Waipara, and included in its territory the Upper Waipara itself, and that a portion of this area was captured by streams like the Okuku cutting back through the Ashley Range. The former explanation appears to me to be the sounder and more in accordance with the evidence at one's disposal.

It is a possibility that the movements producing this basin have ceased only recently—if, indeed, they are not actually in progress. The course of the Ashley through its gorge suggests recent rejuvenation. Throughout

a considerable portion of its course the river is flowing in deeply-incised meanders on the floor of a wider valley, these meanders producing remarkable scenic effects. It is just possible, therefore, that this is due to movements along an old line, similar to those occurring farther north-east at the present time (note the Christmas Day earthquake of 1922), near Waikari, and but recently at Cheviot. The fault-line is therefore one of the Kaikoura series of Cotton, and is producing surface features characteristic of that group of movements.

The streams such as the Ashley, Whistler, and Townshend show evidences of aggrading in their course across Lees Valley, which is quite in keeping with the fact that the interference with the normal grade of the Ashley is recent in point of time.

Evidences of glaciation were looked for but not found. Truncated and semitruncated spurs and groups of knobs at the ends of spurs, so characteristic of glaciated regions, were seen, specially in the valley of the Whistler, but the entire absence of moraines and other proof of glaciation in places where it might be expected negatives this somewhat uncertain evidence. At high levels in the Puketeraki Range there are hollows suggestive of the former presence of corrie glaciers. This range is placed athwart the course of the rain-bearing winds coming from the west, and lies so far east of the main divide that it is unlikely that the eastern slopes, even in the height of the glaciation, nourished any but the smallest of glaciers, and so evidence of the former presence of valley-glaciers is likely to be wanting.

In conclusion, I should like to make a few remarks on the rocks of the Ashley and Okuku Ranges. The only account of these in print is that furnished by McKay (*Rep. Geol. Explor. for 1879-80*, 1881, pp. 83–107), which is somewhat involved and difficult to follow. McKay notes a remarkable variation in the direction of the strike of the beds, especially in connection with the Okuku Range; but in all observations for strikes the general direction was north-east and south-west, even in the case of the Okuku Range, so that they seem to conform to that generally obtaining in the Southern Alps region of Canterbury. No doubt there are local variations, but they are not on a big scale. All through the Ashley Gorge this is the regular direction, although there are cases which depart in both senses from this mean. On a point this side of the bridge in the gorge, where a road-cutting gives a clear section, there is a beautiful example of isoclinal folding, the axes of the folds being E. 10° N., with a northerly dip. At the upper end of the gorge the strike is north-east and the dip south-east, with the dip getting steeper and steeper down-stream till the beds are overturned. There is an occurrence of diabase ash at this point, with the beds striking E. 20° S. and dipping north at high angles, the red- and green-coloured beds being interstratified for several chains. Then again there is a reversion to the normal strike and dip. No fossil was seen in these beds but *Terebellina mckayi*, which occurs in very large numbers in rocks well exposed in a cutting alongside the road just above the point where the river makes the remarkable serpentine meanders near the lower end of the gorge.

Stratigraphical Position of the Charteris Bay Sandstone.

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator, Canterbury Museum.

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IN the author's account of the Geology of Banks Peninsula (*Trans. N.Z. Inst.*, vol. 51, 1919, p. 373) mention was made of a sandstone occurring in places round the head of Lyttelton Harbour, notably at Governor's Bay and at Charteris Bay, which was stated to underlie the rhyolite of that area. When the paper was written no fossils had been found in the sandstone by which its precise age could be determined. However, towards the end of the year 1923 Mr. Orton Bradley, of Charteris Bay, brought to my notice a find of fossils close to the road leading to the wharf. These I considered from a casual inspection of a limited number to show a Senonian facies, and gave this as a tentative opinion in the *Records of the Canterbury Museum* (vol. 2, pt. 3, p. 150). Subsequently a more extensive collection was obtained, and this was submitted to Dr. J. Marwick, the Government Palaeontologist, and he concluded that they were of mid-Tertiary age. This conclusion necessitated a reconsideration of the question of the stratigraphical relationship of the beds in which the fossils occur, so that I made a re-examination of the locality with a view to determining their exact position, and also the age of the associated volcanics.

The fossils submitted to Dr. Marwick came from a large boulder of ferruginous sandstone or grit in the bank close alongside the road, and traces of similar fossils were found in position in a bed about 2 chains away from the boulder and striking in its direction, so that the boulder is not likely to have rolled down the hill for any distance, and may be treated as being practically *in situ*. Although, by the kindness of Mr. Bradley, a good deal of the surface covering of soil and slip material was cleared away, we could not see the fossils in the solid. The number of individuals is large, but they are, unfortunately, represented only by casts and moulds—no shells were seen. The matrix of the fossils also contained numerous small quartz pebbles, so that it might be called a ferruginous quartz-grit.

There are exposures of the same sandstone all along the shore, much intersected by dykes, so that their precise stratigraphical relationship is not easy to make out. The beds appear to have a northerly strike and an easterly dip at moderate angles. However, on the south side of a small bend in the road south of the fossils the dip is reversed and there is a small syncline. At this point, too, there are beds of white sandstone, occasionally well bedded, with layers of harder material interstratified with softer rock. A little distance up the hill towards the south-east a white sandstone has been quarried for building purposes, but owing to the extensive jointing it was found impossible to obtain reasonably-sized blocks, and so the quarry was abandoned. Near it there are also bands of small pebbles in the rock striking towards the spot where the fossils are, so that the white sandstone is in all probability closely associated with the fossil-bearing beds, but the covering of soil which masks the whole surface does not allow this point to be definitely decided.

There is a close lithological resemblance between these beds and those occurring on the saddle between Charteris Bay and the Head of the Bay, where there is a small quarry for road-metal, and also at the various places along Potts Peninsula, specially on the east side, on the end, and on Little Quail Island, which is adjacent thereto. I have examined afresh all these occurrences, and there seems to be little doubt that the sandstone in these places does really antedate the rhyolite. Both the occurrence on the end of Potts Peninsula and that on the west side furnish very strong evidence that this is the case. In the former the sandstone is exposed close down to the sea along the shore-platform, and the rhyolite outcrops just above it on the steep hillside face, but no actual contacts can be seen. This occurrence and that on the adjacent Little Quail Island apparently constitute the denuded core of an anticline, since the rhyolites dip south on the end of Potts Peninsula, and both flows and agglomerate beds dip north on the south side of Quail Island.

On the western side of the peninsula the sandstone underlies the rhyolite, and the same is probably true of the quarry on the saddle at its proximal end. In the former two cases the possibility of faulting is not entirely eliminated, but it seems extremely unlikely. Further, in no case has a remnant of sandstone been observed overlying the rhyolite, and the absence of such a remnant is hard to explain if it be granted that the sandstone is younger than the rhyolite, since there is a very high probability that such would be preserved underlying the andesite somewhere or other round the head of the harbour. The general conclusion is, therefore, that a sandstone of similar lithological character to that containing the fossils does underlie the rhyolite. All the same, on the eastern side of Charteris Bay near the fossils there is no certainty as regards the relationship of the sedimentaries and the rhyolite—one set may as well be underneath as the other, considering the evidence at one's disposal.

The only precise determination of its age is that derived from the identification of the fossils. In a personal communication Dr. Marwick says: "I have had a good look over the Charteris Bay material and have come to the conclusion that it is probably of Middle or Upper Oamaruian age, somewhere from Waiarekan to Awamoan. The most important fossil is the Venerid, of which a large number of casts are present, showing the hinge and the interior of the shell. At first sight it resembles a large *Callista thomsoni* Woods, but the clear casts of the hinge show there was no anterior lateral tooth. This with the smooth margin and disposition of the pallial line proves that the shell is a *Marcia*. This genus as far as I know does not go back to the Cretaceous. In fact, the loss of the anterior lateral tooth in the Veneridae appears to have been a post-Cretaceous development. Suter generally classed these shells as *Paphia*—*e.g.*, *Paphia curta* Hutton. The first known appearance in New Zealand is just below the Aotea limestone in the Huntly-Kawhia district, and the last in the Nukumaruian. I would not like to say whether the Charteris Bay shells belong to a new species or not, as the exterior is not well shown. There are several other genera present,. but only the exterior of the shells is preserved, so their determination is uncertain. The case with strong radial ribs is like *Cardium spatiosum*. I know of no other New Zealand shell with which it could be compared. The Venerid of which casts were made showing concentric ridges may have been a *Marcia*, but I do not think the hinges spoken of above belong to it. It could also have been an *Antigona* or a *Paphia*. The marginal fragment of a large flat shell may belong to a *Miltha*: the sculpture was apparently very weak, and the

inflation not sufficient for a *Dosinia*. There is also a doubtful *Glycymeris*. The rounded closely-placed radial ribs and strong concentric growth-lines remind one of some members of this genus. Apart from the *Marcia*, the general resemblances, though vague, thus favour a Middle Tertiary age."

The conclusions arrived at by Dr. Marwick as to the age of these fossils necessitates the consideration of two alternatives—viz., either our ideas as to the age of the rhyolites must be modified, or there are two sandstones in the district of similar lithological character.

The age of the rhyolites has usually been given as Cretaceous, since rhyolites of similar lithological character occur at Malvern and Rakaia Gorge whose age is definitely pre-Senonian, and there is no reason for considering the Gebbies Pass rhyolites of different age, seeing that their stratigraphical position as well is apparently similar to that of the rhyolites in other localities. Therefore we are driven to consider the possibility of two sandstones existing in the area, one of pre-Tertiary date and the other of mid-Tertiary date. Now, if both occur, both are penetrated by trachyte dykes belonging to the Lyttelton volcanic system, and, as these trachytes are certainly contemporaneous with the building-up of the Lyttelton volcano, it follows that the volcano dates from a time later than the mid-Tertiary, so that it may, after all, be much later than was first supposed. Further, since the volcano was much denuded before the lavas of Mount Herbert were poured out, it makes the date of the Mount Herbert volcano a great deal later than has usually been believed—that is, it is late Tertiary, or even Pleistocene—and this serves to confirm the conclusions drawn from the form of the stream-valleys eroded on the land-surface reaching down from the summit towards Purau and Diamond Harbour.

Results given by Wells at Christchurch Pumping-station, Beckenham.

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 3rd December, 1924; received by Editor, 31st December, 1924; issued separately, 31st March, 1926.*]

A LITTLE while ago I was afforded facilities for examining the records of certain wells at the Christchurch pumping-station at Beckenham, and, as they seemed to afford data of purely scientific interest, I asked permission from the Mayor (Mr. J. A. Flesher) to embody some of the material in a short statement of the facts and of the conclusions to be drawn therefrom. This permission was kindly granted, and hence these notes.

The location of the pumping-station is on the east side of Colombo Street South, about half a mile from the foot of the Port Hills. On an area of approximately an acre, one 9 in., five 8 in., and two 6 in. wells were sunk, being spaced over the area at an average distance apart of about a chain. The water from these was allowed to discharge freely into a tank sunk 12 ft. below the ground-surface, which corresponds with the level of the engine-room floor of the station. This is taken as a datum for reckoning levels at the station, specially those in connection with the flow of wells. The floor of this tank is 3 ft. 9 in. above high

water, spring tide, at Heathcote. From the tank the water is pumped directly into a reservoir on the hills, or into the mains.

These wells were all sunk to the first stratum, and water was obtained in quantity from a depth of approximately 80 ft., the range being between 75 ft. and 85 ft. In order to augment the supply a 14 in. well was sunk at a point 5 chains east-south-east of the tank—that is, 2½ chains from the nearest 8 in. well—and yet another 6 in. well about 2 chains farther on in the same direction. In order to obtain a supply from a greater depth a bore was sunk to a depth of 610 ft. at a spot 5 chains north-east of the tank. The hope of striking a reasonable supply from a deeper stratum was not realized, and the pipes were drawn up to the 75 ft. level, from which a flow of over 300 gallons a minute was obtained even while the other wells were being drawn on.

The first point concerning which comment appears appropriate is the record of the beds passed through in the case of the deep bore. The log is as follows:—

	Feet.	
Surface clay ..	3	
Blue gravel ..	15	
Blue sandy clay ..	41	
Sandy gravel ..	64	
Water gravels ..	86	Gave flow of water 250 gallons per minute at 78 ft.
Sandy gravels ..	113	
Sand	162	
Sand and gravel ..	169	
Sand	174	
Gravel and clay ..	189	
Sand	193	
Clay and yellow sand	229	
Volcanic rock ..	234	Containing pebbles of basalt.
Fine blue sand ..	236	
Rough gravel and sand	251	Water rises 9 ft. above surface, flows 30 gallons per minute.
Grey sand and gravel	278	
Soft blue sand ..	305	
Stiff blue clay ..	347	
Soft blue sand and pebbles	355	
Fragmentary volcanic rock	370	
Soft blue sand ..	385	
Sandy blue clay ..	443	
Volcanic rock ..	445	
Blue clay and sand ..	450	
Sandy blue clay ..	536	
Soft rock	538	
Blue sand	550	No water. End of pipe.
Blue sand to ..	610	No water. Last 60 ft. merely drilled.

This log shows a considerable difference in the beds as compared with those disclosed in the records given by ordinary wells of the Christchurch area. First of all, there is a marked deficiency in the thickness of the gravel and a great increase in the amount of sand and sandy clay. (For example, in record of well at Sydenham Water-tower, given in a paper by

the present author entitled "Preliminary Account of the Geological Features of the Christchurch Artesian Area"—*Trans. N.Z. Inst.*, vol. 43, 1911, pl. 12, col. 4, facing p. 429.) An occasional shell-fragment was reported from the sandy beds, confirming the records of adjacent wells in which shells have also been encountered (*loc. cit.*, pl. 12), and this almost certainly shows that the beds are marine in origin. It is possible that such shells may be fresh-water, but well-sinkers have told me that they are the same as those now found on the beach. I have seen none myself. This occurrence almost certainly shows that the sea extended over the area where the beds were being laid down, while gravels were being deposited either on a land surface or near the mouths of fast-flowing rivers in adjacent parts of the area. In the vicinity of the station they were probably laid down on a land surface, since totara-trees with their roots in position were encountered below high-water mark while the tank was being sunk. The marine beds just referred to follow right round the base of the hills towards Heathcote, and show that before the upper-stratum gravels were laid down a lagoon or arm of the sea, or perhaps an estuary, extended all round this sector of Banks Peninsula.

Another point concerns the presence of pebbles of volcanic rock at several horizons. These prove to be basalt or related basic rock similar to that occurring on the neighbouring Port Hills. Its presence shows that, with the exception of the upper gravels, a very important part of the coarse detrital constituent of the beds was derived from a source entirely different from that which supplies the gravel for the other part of the area. It also shows that these beds are later than the Lyttelton volcanics, a point which is apparently not very clear to some people. The beds of volcanic pebbles probably formed beaches along an old shore while finer-grained sands and sandy clays were being laid down in slightly deeper water. There does not appear to be any definite association of these beds with artesian water.

The levels at which such volcanic pebbles occur are to some extent accordant with those of other wells along the base of the hills. For example, such pebbles occur in the Beckenham bore at 234 ft. and 355–370 ft.; in the well at Heathcote Valley pumping-station at 355 ft.; and in well at Rat Island, in the Estuary, at 238–247 ft. and at 385–386 ft., the last-named according to the log of the bore kindly furnished me by Job Osborne and Co., well-sinkers. The presence of pebbles at these two levels perhaps indicates that the depth of water along the base of the hills was about the same for a considerable period in order to allow a general drift of coarse material for some distance off-shore. Volcanic pebbles occur at other levels in the sandy beds besides those just mentioned, specially just above the solid rock, where they are associated with weak flows of water, which probably finds its way down from the hills along its upper surface. The persistence of the volcanic pebbles at the levels just mentioned may, after all, be a mere coincidence and have no special significance.

The depths at which water is encountered in the fringe round the hills is also fairly close, allowance being made for slight variations in the level of the surface of the ground. In the Beckenham bore they are at 78 ft. and 251 ft., and similar occurrences can be seen in the records of wells given in my former paper (*loc. cit.*, pl. 12, cols. 6, 8, 11, 12, 15). This may also be only a coincidence, but it is what might reasonably be expected, since marine conditions must have been much the same at the same levels off an old shore, in contradistinction to conditions when gravels and associated beds are laid down on a land surface. All the same, the shallow

stratum at Beckenham does not belong to the system fringing the hills, but is due to the invasion of the marine area by land beds. That this is really the case is shown by the roots of totara-trees in position, which were discovered when the excavations for the tank were being made.

It is thus fairly clear that the arm of the sea or an estuary was gradually encroached on by gravels brought down by rivers, which covered up the marine deposits and caused a gradual extension of the "first stratum" series of beds up to the base of the hills; so that first-stratum water is generally obtainable, except in such places as Heathcote, where the gravels have not extended far enough and where the topmost beds still consist of sands and sandy clays similar to those now being laid down in the adjacent estuary. The top layers in this place are merely the extension landwards of these later estuarine deposits.

This fringe round the hills, not intimately connected with the general artesian system of Christchurch, cannot extend out very far beyond the pumping-station, since a well 5 chains farther north-east beyond the deep 6 in. well gives a plentiful supply of water from a deep stratum not existing in the 6 in. well. In this case a 2½ in. pipe gave, when the well was first sunk, a flow of 100 gallons per minute from a depth of 365 ft., and water rose 25 ft. above ground-level. The first-stratum water of this well reached to only 2 ft. below the surface of the ground; but this level must be fully 7 ft. above the ground-level at the 6 in. well, since it is on a high terrace of the river, and the apparent failure may thus be accounted for. This prolific 365 ft. stratum has no counterpart whatsoever in the well at the pumping-station, for at that depth there occurs a bed of fragmentary volcanic rock, but no water. Similar records can be got from other wells just outside the station limits, which confirm the results from the well just cited.

Consideration was also given to the source of the water at the 251 ft. level. It appears to me that this cannot be credited to water which has come down from the Port Hills as distinct from that which supplies wells generally. The 6 in. well rises 9 ft. above the surface, and a similar rise is recorded in other wells—13 ft. in the case of the well at Mrs. Cocks's, and 15 ft. in the case of the Heathcote Racecourse well. Now, it does not seem to me at all possible that this rise can be obtained by the pressure due to a head of water from the hills. This would demand that the water-bearing bed should rise against their flanks for a distance of quite 20 ft., or even more, above the level of the plain, and there is no evidence of this. Rather it appears to me the water comes from the ordinary supply, but that, owing to the high coefficient of friction in such water-bearing beds as extend into the marine beds in this area, the supplies are comparatively poor. No doubt tongues of gravel, gradually diminishing in thickness and perhaps increasing in compactness as the percentage of finer material increases, were pushed forward from the land-surface which existed to the north and west, and along these the supplies of water found their way, but in diminishing quantity. Although these beds do not obtain their supply from the hills, there is every reason for thinking that the supplies obtained from just above the solid rock substratum do come from there; but solid rock was not reached in the deep bore at Beckenham, although it was in all probability not far away, so the question of a supply from just above it does not arise in connection with this discussion.

The next point to be considered is the amount of flow from the wells at Beckenham. This is extraordinarily great considering that it is from the first stratum. The records of the Venturi meters installed in the station show that when the surface of the water is lowered till it stands at 5 ft. 6 in. above the floor of the tank the yield from seven wells (not

including the 14 in. well) was 1,623 gallons per minute; with the depth of water in the tank standing at 4 ft. 6 in. the flow was 1,669 gallons per minute; and with the level of the water standing in the tank at 3 ft. and the 14 in. well flowing the total reached 2,686 gallons per minute, and this was while a 6 in. well 5 chains away was running to waste over 300 gallons per minute. As far as can be seen, this amount can be maintained, because, strange to say, the sinking of the 14 in. well resulted in increased flows being given by the others.

This amount is very great, seeing that it is practically the yield to be obtained from a little over an acre of ground; still, it is of the same order as is at times obtained from first-stratum wells in the Christchurch area: *e.g.*, a 3 in. well in the Botanic Gardens gives a flow of 80 gallons per minute, and this flow has been maintained for several years. But there appears to be an extraordinary concentration at Beckenham, which may be explained in two ways:—

(1.) The major portion of the supply is obtained from a leak from a deeper stratum. Now, if this is the case it must be from a deep stratum not under the present wells but some distance farther from the hills. It might appear quite feasible that water should leak up the contact between the beds of the fringing area and those of the Christchurch area, were the contact definite, and thus fill the overlying bed. But if this is the case, then the pressure to be obtained from the first stratum should be much higher, unless friction is very great, or unless there is a ready outflow from somewhere near to lower the pressure. This may be furnished by the big springs in Beckenham Park, which lie approximately 37 chains south-east of the pumping-station and yield over 1,000,000 gallons per day. This water may, after all, not be a true spring, but a leakage from the river at a higher level coming directly across a loop. Also, I do not think there is a definite line of demarcation between the two sets of beds, but one dovetails into the other along their line of junction.

(2.) The increased supply is due to the obstruction afforded by Banks Peninsula to the movement of the underground streams. This may be explained in some such way as the following: In that sector of the plains lying behind the mass of Banks Peninsula the water is continually finding its way seaward, following along the different underground permeable beds. North and south of the peninsula there is no obstruction to this movement except the friction of the beds themselves. Owing to this friction they give a flow which diminishes progressively as the beds are followed north parallel to the coast-line past Kaiapoi to the line of the Ashley, and on following then south towards the mouth of the Rakaia. The prolific yields are in the vicinity of the volcanic mass, and especially in close proximity to it. This may be explained by the water being concentrated in more or less well-defined streams as it forces its way past the obstructions, and specially is this the case on the northern flank of the volcano; and where such concentrations are tapped great yields are obtained. This would also account for the springs at Beckenham Park and at Hoonhay. The latter lie just where the obstruction is placed right across the normal path of underground water-movement, and the yield is very great—viz., 3,000,000 gallons per day. This appears to me the reason for the abnormal concentration at Beckenham. All the same, both causes may be operative at the same time, and the second cause may promote abnormal concentration of the flows in deeper beds as well as in the shallow ones, and the springs at Hoonhay may be due to an upward leak from a deep stratum, perhaps following initially along the contact of the gravel-beds with the underlying volcanics.

In order to test the interference of one well on the flow of another I suggested to the Engineer that tests could be made by shutting down sets

of wells progressively and noting the effect. The following results have been obtained :—

First of all a comparison was made between the original four wells put down and a subsequent three wells. The former constitute an inner ring consisting of two 6 in. and two 8 in. nearest the station ; included in this should be a 9 in. well, but this is unsatisfactory, and yields only 20 gallons per minute, and for that reason is excluded from the test. The wells are uneven in yield, and the best results are obtained from one of the 6 in. wells. The latter set of wells consists of three 8 in. wells placed on a line approximately 3 chains from the tank. The tests were made with the water at an average depth of 2 ft. 6 in. in the tank, the measurement made by noting the time the water-level took to rise from 2 ft. to 3 ft.

The four original wells (two 6 in. and two 8 in.—all other wells shut off) gave 1,538 gallons per minute ; the three 8 in. wells (all other wells shut off) gave 1,205 gallons per minute : a total of 2,763 gallons per minute. The whole seven (all other wells shut off) gave 2,205 gallons per minute. This means a loss of about 20 per cent. due to interference of one set with the other. The 14 in. well and the 6 in. coupled with it (all other wells shut off) gave 846 gallons per minute. All wells open except the 9 in. gave 2,686 gallons per minute. This amount combined with the previous total from the former set of seven wells should be 3,051 gallons per minute, which shows an interference of only 8 per cent. The small amount is probably due to the last two wells being an average distance of 3 chains away from the set of 8 in. wells. This interference is comparatively small.

Both these results are apparently lower than the values given by Schlichter (Theoretical Investigation of the Motion of Ground-waters, *19th Ann. Rep. U.S. Geol. Sur.*, 1897–98), and are indicative of the largeness of the supply.

Considerable value is attached in some quarters to the amount of water yielded per square inch of well cross-section. Of course, there is a falling-off in the quantity reckoned this way in the case of larger wells, and therefore it may appear at first sight that the advantage lies with a number of smaller bores rather than with a smaller number of larger bores of equal total sectional area. No doubt the smaller bores exhaust an area more thoroughly if a sufficient number are sunk, but then the question of cost arises, and the larger wells may be more economical in the long-run as giving a greater return per money expended. There is another advantage in the case of wells in the Christchurch area—viz., that large-bore wells, if not so prolific per unit of area, yield their water quietly, and so a smaller quantity of sand, and at times of stones, is carried into the settling-tank. If no settling-tank is provided, then the wear on pumps, valves, &c., must be serious. Oscar Edward Meinzer, in his paper on the Occurrence of Ground-water in the United States (*U.S. Geol. Surv., Water-supply Paper 489*, 1923, p. 119) says : " By coming into wells after they are finished, it [the sand] damages the pump, sometimes erodes the casing, and frequently clogs the wells." The first two reasons appear to be of special importance in the case of wells in the Christchurch area, so that any means of diminishing the disability arising therefrom, unless too great an expenditure is incurred, should be followed out. By sinking wider bores the rush of water is reduced, and the objection to the presence of the sand in pumps, &c., partially or completely removed.

In concluding this brief statement I have to express my indebtedness to the Mayor for kindly allowing me to use the records ; also to Mr. C. Dawe, the City Surveyor, and to Mr. F. Mellish, Engineer at the pumping-station, for substantial and ready assistance whenever they were called on.

Artesian Wells of the Christchurch Area.

By F. W. HILGENDORF, M.A., D.Sc., F.N.Z.Inst.

[*Read before the Canterbury Philosophical Institute, 3rd December, 1924; received by Editor, 31st December, 1924; issued separately, 31st March, 1926.*]

CONTENTS.

A. OBJECTS AND METHODS.

THE investigations here recorded were carried on by the writer with the assistance and advice of the Artesian Wells Committee of the Canterbury Philosophical Institute, the monetary expense involved being met by a grant to that committee from the New Zealand Institute. The work dealt with in this report was started in 1921, and was carried on almost continuously till November, 1924, by which time it appeared that the number of new facts likely to come to light by the method used was not commensurate with the labour involved in discovering them. The writer has been making observations on the Christchurch artesians for the past fourteen years, and the information gained has been largely drawn on for comparison with the results of this series of observations.

The ultimate aim of the research was to enable a prophecy to be made as to the future fate of the wells—whether the supply is likely to become insufficient as the draft on it increases, and whether the level to which the water rises is likely to diminish in the course of years.

For this purpose it was sought to find the source of the water supplying the wells, and the quest was started along two lines: first, recorders giving continuous readings were attached to a number of wells, and meteorological observations were made or collected, to see if there were any correlation between the level of the waters in the wells on the one hand and such things as rain, evaporation, river-floods, &c., on the other; and, second, chemical analyses were made of the waters from various wells and the possible sources of supply to see if there were any chemical similarities between their compositions.

B. THE WATER-LEVEL OBSERVATIONS.

These were made on eight wells varying in depth from 60 ft. to 344 ft., and situated either in Christchurch or at Lincoln, twelve miles from Christchurch. Wells have to be out of use for the purposes of water-supply while continuous records are being taken of their static head, and this largely restricts the number of wells available, so that frequently one has to go far afield to secure wells of the desired depth.

The arrangement adopted for securing the records consisted of (1) a float-chamber at the top of the well-pipe: (2) a float connected by cords and pulleys with a pencil, to which movements of the float imparted a

series of vertical movements: (3) a drum rotating on a vertical axis, driven by clockwork, and carrying a paper on which the pencil marked the records. The float-chamber was 6 in. in diameter and 6 ft. in height; it was so arranged that at the time of its erection the static level of the water was about the middle of its height, so that the water might rise or fall about 3 ft. before putting the float out of action. The float weighed 3 lb. and was connected with the pencil by thin steel wire, which was proved, by trial of the apparatus on standing water, to impart no motion to the pencil by such alterations to its length as were produced by the weather variations to which it was subjected. The rotating drums were 18 in. in height and about 1 ft. in diameter: they rotated once a week, were driven by hanging weights, and their timing was regulated by their being belt-connected to large kitchen clocks of the "Big Ben" type. These recorders worked perfectly well indoors, but in the temporary shelters erected over the wells they were apt to stop working in wet or cold weather, so that important records were sometimes lost, and the necessity for winding them daily made them expensive to look after when they were far apart. In the end a barograph, in which the vacuum-box was disconnected from the recording-pen, was modified for use on the wells, and its weekly winding and regular running made it perfectly satisfactory in action.

The instruments (three in number) were first attached to three wells in Christchurch, all situated near Canterbury College; but many small movements, and the beginnings of larger ones, are, in the town wells, masked by the effects of intermittent pumping from neighbouring wells. For the study of these smaller fluctuations the instruments were moved to Lincoln, where pumping from the wells is not practised; and this removal was rendered additionally desirable because there were indications of fundamental differences between the wells at Christchurch and those at Lincoln. In the following paragraphs the behaviour of the town wells and those at Lincoln are frequently contrasted.

At one stage of the observations a recorder was placed on the River Avon, and some of the observations made are recorded in the final paragraph of this section.

1. The Rain Effect.

(a.) *The Wells at Lincoln.*

Size of the Effect.—That rain raises the level of the water in the wells is common knowledge. The amount of rise produced by 1 in. of rain varies greatly with the condition of the soil and subsoil before the rain concerned. If the rain comes after a drought its effect on the well is only slight; if it comes after previous rains its effect is much more pronounced. This is probably because in the first case all the rain does not reach the free subsoil water at the outcrop of stratum whose water supplies the well, but is used up in moistening the soil and subsoil: if this is already wet by previous rains nearly all the subsequent fall reaches the water-table. In many places a saturated soil and subsoil would increase the surface run-off instead of raising the water-table, but over the greater part of the plains above Lincoln the soil is so gravelly and pervious that there is no run-off at all. Thus of two equal rainfalls occurring at a short interval of time the second has an effect much greater than the first, because the second fall is not called upon to moisten the soil before it reaches the water-table. It is therefore not possible to state

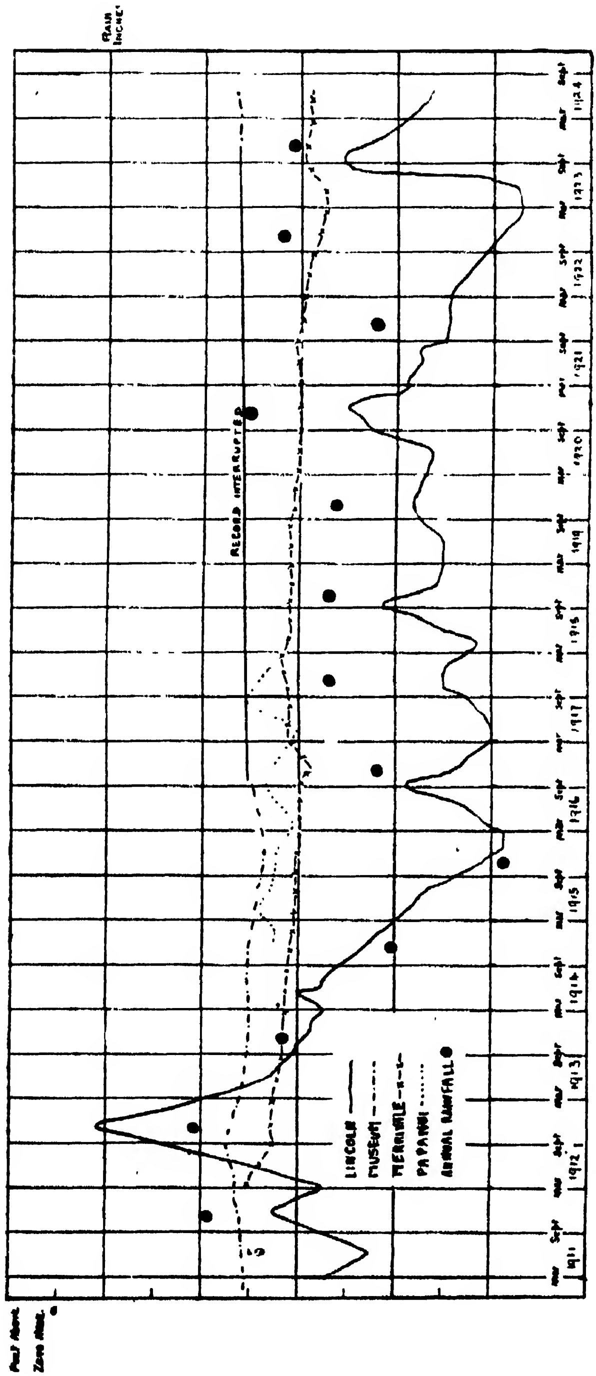

FIG. F1 rio wells.

the effect of any given amount of rain on any given well. Consecutive rains have a cumulative effect. This cannot be made clearer than in the graphs illustrating former papers on this subject (2, 3) or that given in less detail in fig. 1 of the present article.

The maximum variation in well-level recorded in these observations is in a 344 ft. well at Lincoln College, which stood at 8 ft. 2 in. above zero-mark in 1912, and fell to 9 in. below zero in 1923. This must not, however, be considered a permanent fall, because the great height of 1912 was attained only after two annual rains of 32 in.—28 per cent. above the normal 26 in. In 1911 the water-level was only 2 ft. 6 in., and two wet seasons produced a rise of nearly 6 ft. It is almost certain that similar seasons in future would produce a similar rise, and that much of the uneasiness concerning the present level of the wells will be allayed when a few wet years have again been experienced. The year 1914 had only 20 in. of rain, and 1915 only 14 in., so that the wells fell seriously. Since then we have had almost normal rainfalls. but nothing to counterbalance the serious drop in the wells following on the years of drought.

The maximum rise after a given rain was recorded on a 308 ft. well at Lincoln, where a rise of over 18 in. followed the 4 in. rain in May, 1923. How much more than 18 in. the rise was could not be ascertained, because the water overflowed the top of the pipe (which was already 25 ft. above the ground) and it became necessary to shut off the well.

This particular well (the old creamery-well at Schaeffer's Corner) was sunk in 1902; its depth was 308 ft. The water rose 25 ft. above ground-level, and the 2 in. pipe discharged 25 gallons per minute at the surface. The height is still 25 ft. after a rain, but the surface discharge is only about ½ gallon per minute. This is a case of blockage of the pipe, and the flow could be restored by reboring the present pipe. The reduced flow of a well whose static head is also reduced cannot be restored by any manipulation so far known.

At the time of the 18 in. well-rise described the rainfall at Lincoln was only 4 in., but it was 13 in. at Darfield, which may be considered as nearer the outcrop of the stratum tapped by the well. The College well (344 ft.) rose about 17 in. on the same occasion. There also the exact rise could not be measured, as the water had sunk to below zero on the gauge before the rain mentioned.

The amount of rise per inch of rain is governed by the distance the water runs over impervious strata before it falls into the pervious one that is tapped by the well. The rise of any well therefore varies with the nature of the layers at the outcrop of the stratum tapped, but all near-by wells sunk to the same depth probably react similarly.

Hutton (4) notices that his deep well fluctuated more than his shallow one, and I have found that in general deep wells rise more than shallow ones per inch of rain. While the greater number of shallow wells in town is a sufficient explanation of the phenomenon there, other factors must be called in to explain it in the country, where shallow wells are not in excess. It may be supposed that the strata tapped by the shallow wells reach the surface near the artesian area, while those tapped by the deep ones reach the surface higher up the plains. The farther up the plain (within limits), the more shingly is its surface; the nearer the sea, the more is its surface clothed with soil. Rain falling close to Lincoln sinks slowly and imperfectly to the strata tapped by the shallow wells: rain falling farther away sinks rapidly and completely to those tapped by the deeper ones.

It is probable that the rain feeding the wells falls within, say, ten miles of Lincoln or Christchurch, and not far up the plains, or in the mountains, as is sometimes supposed. A popular belief connects the snows on Mount Torlesse with the artesian water-supply, but this is almost certainly fallacious. All the snow that melts off Mount Torlesse must be caught by the Kowhai or the Waimakariri, and its effect on the wells must be by way of the river. To the river, however, the effect of Torlesse snows is negligible in comparison with the snows it receives from other quarters, and so the effect of Torlesse snows on the wells must be negligible too. Benmore snow may conceivably affect the Lincoln wells, because, although much of it finds its way to the Kowhai and Waimakariri, a certain amount is fed to the Selwyn, which loses itself in the middle plains, and so may affect the seaboard wells. Years of observation have, however, failed to show any relation between the melting of the snows on the frontal range and the fluctuations in the water-level of the artesians.

It is true that the Lincoln wells often reach their annual maximum in October–November, at the end of the melting of the mountain snows, but an examination of fig. 1 will show that there was a continuous fall during 1914 and 1915 with no maximum in early summer, although snow-melting took place as usual; and the same is true of 1923. The graph, moreover, shows the all-sufficiency of the rainfall near Lincoln to explain all the major fluctuations of the well-level, without calling in the aid of any such supposititious factors as the snow on the distant ranges.

Time of the Rain Effect.—Next to the amount of the effect due to rain, the length of time taken for the influence of the rain to be felt on the well calls for consideration. To find out this time is not as easy as was anticipated when the recorders were installed, for the wells respond to barometric changes as well as to rainfall. The wells fall when the barometer rises, and the barometer almost invariably rises when rain commences. Thus the first effect of rain is to make the well-level recede, and this effect has to be overcome before the rain rise is observed. However the barometric effect on certain wells has been determined and can be allowed for with fair accuracy. In the best case noted the fall due to barometric rise was checked, stopped, and reversed within two hours of the start of a fall of rain; but in other cases the effect was much more retarded. When the ground was very dry in May, 1923, and then 4 in. of rain fell in one week, it took two days before any rise was recorded—and this on the same well that on another occasion had responded to rain within two hours. It would appear that the time taken to cause a rise depends entirely on the time taken for the rain to reach the water-table where the water-bearing stratum outcrops, and that the effect is then immediately imparted to all parts of that water-body, including the part standing in the well-pipe. This would require that we suppose the water-supply to be practically an underground lake among the stones of the gravel-beds; that water is pouring into one end where the bed outcrops on the plain, and out of the other end by means of springs and flowing wells. The spaces among the stones must be very great to allow of such free movement of the water as this rapidity of effect implies, and that large spaces do exist is emphasized by Dr. Chilton's record (1) of subterranean Isopods up to nearly 1 in. in length from the gravels tapped by the shallower wells.

(b.) *The Town Wells.*

Size of Rain Effect.—This is much less in town wells than in those at Lincoln, doubtless because many wells are sunk to the same stratum, and

when a rise takes place every well flows more freely and so any one of them is prevented from rising remarkably. No records were being taken on town wells in May, 1923, when a rise of over 18 in. was recorded in a country well, but inquiries showed that the rise was probably about 6 in. Speight (5) notes "a jump of 6 in. after several days' rain," and this must be considered a large rise for a town well. The great steadiness of the town wells as compared with the country ones is well shown in fig. 1. This is of great interest and importance, for it probably shows that the town wells are normally at their basic level, below which it is improbable any influences will lower them. The source of supply is of such constancy that periods of drought affect them but little. The country wells, being few in number, are normally above their basic level, and therefore are quickly lowered by rainless seasons. This was probably the condition of the town wells in their early days.

Time of Rain Effect.—The town wells are so much influenced by pumping from neighbouring wells to below their static head that all minor fluctuations caused by the weather, and the beginning of all larger ones, are totally obscured. There is therefore no evidence of the time after rain that the town wells begin to rise. Symes's (6) suburban well was partly freed from the effect of near-by pumping, and he got the record of a rise within one hour of the commencement of rain—which is of the same order as the two hours noted at Lincoln.

2. The River Effect.

(a.) The Wells at Lincoln.

These might be affected by either the Waimakariri or Selwyn. As the Waimakariri leaves the mountains it is pointing straight towards Lincoln, and does not swing off to the north till it reaches Halkett. From Halkett to Lincoln is about fifteen miles, and the fall of the surface of the plain, and probably of the underlying strata as well, is direct from Halkett to Lincoln, and not from Halkett to Kaiapoi, as the river now runs. It is therefore quite conceivable that seepage from the river reaches Lincoln. The Selwyn runs underground for the middle fifteen miles of its course, disappearing under the shingle above Greendale, and reappearing above Ellesmere. There is every probability that this underground water seeps away to be tapped by wells, and does not all rise again in the river-bed. Mr. W. Turner, of Selwyn Railway-station, kept a record of the floods in the Selwyn for me for some years while I tried to find a reaction to them in the Lincoln wells.

No effect from Waimakariri or Selwyn has ever been recorded as the result of direct observation in any well at Lincoln, and the five months graph shown in *Trans. N.Z. Inst.*, vol. 44, p. 147, is pretty conclusive evidence that no such effect occurs as far as the larger river is concerned.

In 1914 we had 20 in. of rain, and in 1915 14 in., compared with our average of 25 in. As a result of this, some springs at Brookside, two miles from the Selwyn River, went dry. In 1916 a heavy rain occurred, causing a flood in the Selwyn, and a fortnight later the Brookside springs started running. This is sufficient evidence that the Selwyn feeds underground reservoirs; but if the flood-water when underground travels at the rate of only a mile a week, it would be impossible to trace cause and effect in the case of the Lincoln wells, which are twelve or fifteen miles away from any possible seepage-bed in the Selwyn.

The slowness of travel of the water on this occasion serves to emphasize the rapidity of the rain effect, and to support the idea that the ordinary source of supply is either a virtual underground lake, or freely-moving underground streams whose intake is quite close to the wells. In the present case one may suppose seepage from the river to these springs to take place only from flood-waters, and therefore through usually dry beds which would greatly retard the water's flow.

While floods in the rivers cannot be traced in the fluctuations of the wells, yet a steady seepage is to be regarded as very probable. From early in 1914 till February, 1916, the 334 ft. well at Lincoln College fell steadily and uninterruptedly from 4 ft. above the zero-mark to 4 in. below it. Then, though the weather continued dry, and although a continuation of the fall might have been expected, the diminution of static head ceased, and the level remained constant until the 28th May, when heavy rains caused the well to rise. In November, 1922, the well-level had again fallen below the arbitrary zero, and again remained about 4 in. below until late in May, 1923, when the heavy rains of that month caused the water to reappear in the gauge. On neither of these occasions did a ram whose intake-pipe is only 11 in. below zero on the gauge cease to work. That on two occasions of long and constant fall, the fall should be arrested at the same level without any rain to check it, clearly suggests a source of supply more constant than the rainfall alone. It looks as if there were a constant supply held by river-seepage to a certain level, and when heavy rain falls this level is raised considerably, because the few wells at Lincoln (four or five per square mile) do not let the water away quickly enough to check the rise. In course of time, however, the increased level due to the rain is reduced, and the wells then stand, and continue to stand, at the level of the water as supplied by the rivers. This evidence of the river-supply would not be sufficient to prove it if Lincoln wells alone were considered, but the evidence from the town wells to be next considered is very strongly in this direction.

(b.) *The Town Wells.*

Here there are many thousands of wells per square mile, and their combined flow is much over 10,000,000 gallons per day. These wells are very constant in level, as shown in fig. 1. They rise with rain, but to a much less extent than the country wells, and quickly fall back again to their constant level, below which their continuous and voluminous flow is not able to reduce them. The evidence in favour of river-supply is practically conclusive. The rainfall is, indeed, sufficient to supply the flow, but the rainfall is intermittent, while the wells, once the rain has ceased for a few days, remain at a level that is practically constant.

The relative constancy of the town wells compared with the country one (fig. 1) indicates that the former are using chiefly river-water and the latter chiefly rain-water. No observation of a well's rising after a Waimakariri flood has yet been made in any well farther from the river than Belfast, despite the general impression that such a rise takes place. Speight (5) suggests that barometric influence may cause the apparent connection, and the next section will show that this surmise is probably correct.

3. THE BAROMETRIC EFFECT.

(a.) *The Country Wells.*

The effect of the variations of the barometer previously recorded (1) were found again in every record made during the present series of

observations, but were differently developed in different wells. The Lincoln College well (344 ft.) rises four times as much as the barometer falls, but a near-by well of 60 ft. in depth showed a water-rise only equal to the barometer-fall. A typical week's graph for this well is reproduced (fig. 2), the well reading being inverted.

(b.) The Town Wells.

Here no connection between barometer and well-level has ever been recorded, because the effect of pumping adjacent wells below their static head masks all small fluctuations to such an extent as to make accurate measurements impossible. The barometric effect must, however, be present in full force, and if it has anything like the effect it has at Lincoln the result must be quite striking. Hutton's graphs (4) show that rises of 4 in.

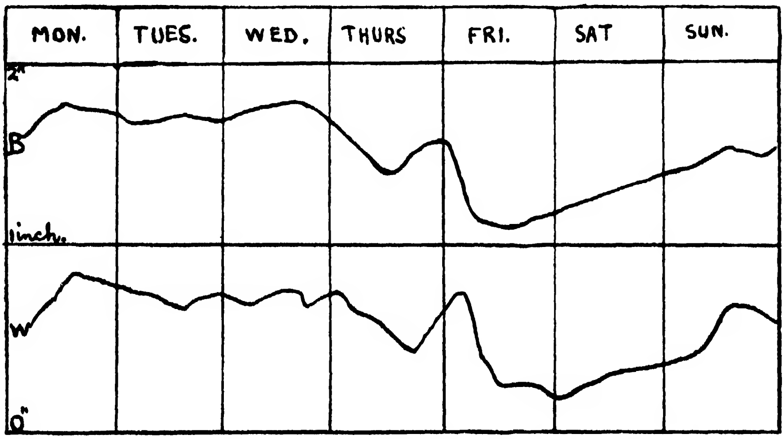

FIG. 2.—B, barogram; W, inverted record of 80 ft. well at Greenpark.

are quite uncommon, and would cause a noticeable difference in the flow of a well or the working of a hydraulic ram. But a rise of this sort, if not of this amount, must be produced every time the barometer falls 1 in., which it does every time a north-wester blows; and this is doubtless the cause of the general observation that rams work better during a north-wester or when the Waimakariri is in flood.

4. THE INDUSTRIAL EFFECT.

This is the name suggested by Dr. C. C. Farr for the interference with the static head of the well under observation by pumping other wells to below their static head. For the circumstances concerned it is a better term than "interference," which includes also the effect caused by the sinking of new wells and the opening and closing of old ones in the neighbourhood of that under observation.

(a.) The Country Wells.

No industrial effect was observed here, because pumping direct from wells is not practised in the neighbourhood. This absence of industrial effect allows other effects to be more closely seen.

(*b.*) *The Town Wells.*

The industrial effect was first noted by Captain Hutton (4), who states that the shallow well at the Christchurch Museum rose every evening, and who was able to assign this to industrial causes, because no corresponding fall took place on Sundays or holidays. Hutton's "evening rise" was perfectly well marked, and it was to see if the rise were really an industrial effect that observations on country wells were first started. There appeared some slight evening rise in my first observations (2), but the present series shows it to be much greater in town, and to be really industrial in origin. Instead of an "evening rise" it should be called a "morning fall," because the higher level is the normal one, and the lowering is produced by pumping. The Museum wells, observed by Captain

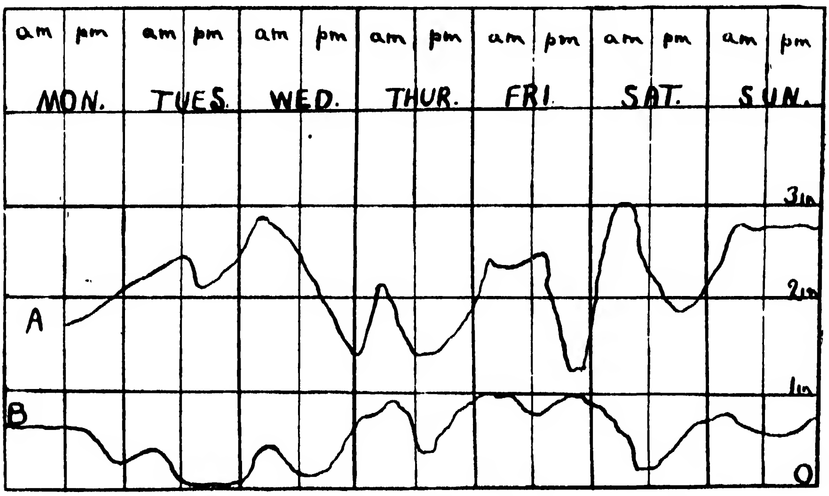

FIG. 3.—Industrial effect on—A, well near Hospital; B, Symes's Papanui well.

Hutton and Professor Speight, and the three wells recently under observation, are all within half a mile of the industrial quarter of the town, and so they promptly feel the effect of pumping. The places and times of pumping have been traced, and the accord between start of pumping and falling of well is almost exact. Symes's (6) records show daily curves with maximum and minimum similar to the wells observed nearer town, but owing to his well being about three miles from the industrial part of the town the curves are somewhat more gradual. A week's graphs (not the same week) from Symes's Papanui well, and one from a well near the Hospital, are here produced for comparison (fig. 3). The absence of a fall on Sunday is again to be noted.

These fluctuations will now be seen to mask any due to barometric effect.

5. EVAPORATION EFFECT.

It was once suggested that the fluctuations of a well's level would be completely understood if one knew the rainfall and the evaporation. This was an attempt to explain the fact that rainfall in dry weather has a much less effect on the wells than the same rainfall in wet weather. An

evaporimeter was therefore installed, consisting of a tank 4 ft. square and 2 ft. deep, placed in the middle of an open field, and kept filled with water to within 2 in. of the top. Observations were made during five years, and the records show for each month the total evaporation, the rainfall, and the "effective rainfall"—that is, the rainfall minus the evaporation.

When the well-levels were graphed against the "effective rainfall" there was no appearance of accord.

Average Monthly Rainfall and Evaporation from a Water-surface at Lincoln, N.Z., for the Years 1916–23 inclusive.

(All in inches.)

Month.	Average Rainfall.	Average Evaporation.	Average Effective Rainfall.
January	3·4	5·4	—2·0
February	1·6	4·5	—2·9
March ..	1·0	4·0	—3·0
April ..	1·8	2·8	—1·0
May ..	2·3	2·1	+0·2
June ..	2·2	1·1	+1·1
July ..	1·8	0·8	+1·0
August	1·6	0·8	+0·8
September	2·5	2·7	—0·2
October	1·6	3·5	—1·9
November	2·1	4·1	—2·0
December	1·5		—4·0

It is thus seen that the effective rainfall is highest in midwinter, while fig. 1 shows that the wells are highest in early summer. The fact is that it is not the evaporation in the month that the rain falls in that modifies the action of the rain upon the well, but the evaporation in previous months. If this has been slight, a normal rainfall has a great effect. Thus the lack of evaporation during winter causes the spring rains to influence the wells so that their maximum height is reached in October and November: the great evaporation during summer causes the autumn rains, though equal to the spring ones in amount, to have little effect, so that the wells reach their minimum in April and May. The variations in height of the wells are governed by the rain modified by the previous evaporation.

The utility of a rainfall from an agricultural point of view is inversely proportional to its effect on the well-levels.

The average rainfall for the five years concerned was 23·4 in., and the average evaporation 37·3 in.

6. Tide Effect.

Professer Speight shows (5) that a tidal effect amounting to 18 in. rise at high tide, and extending to three miles from the coast, occurs at New Brighton. The wells noted in the present series of observations are too far from the sea to show any tide effect.

7. PRESSURE EFFECT.

Symes (6) shows that a tram-car, especially the heavy water-carrying type, produced a distinct wave-like movement in the water in his well, 30 ft. from the tram-line. Speight also refers to trials in Japan showing rise of water in response to artificial loading. This might account for some of the rise in coastal wells due to the rising tide, but the saltness of the New Brighton wells is against the pure pressure explanation. The rise of wells in response to rain may also be partly due to the weight of water falling on the earth—partly only, because the rise in the wells goes on long after the rain has ceased falling. The first rise, however—that occurring within the first hour or two of the rain—might conceivably be associated with pressure effect. I was at first inclined to think that, if the well-rise were due to pressure, every rain should produce the same rise; but, again, it is conceivable that air in the soil, after a period of drought, might cushion the rain's pressure so as to postpone its action. Pressure may therefore have some slight influence in causing the first rise due to rain; but the magnitude of the total rise, its continuance after rain ceases, and the want of any sign of break in its continuity, all indicate that the pressure effect is of very little significance.

8. EARTHQUAKE EFFECT.

Mr. L. P. Symes has kindly allowed me to insert here a note on an observation he made in 1917. In August of that year he was still running a continuous recorder on his Papanui well, as he has previously described (6). At about 0.45 on Monday, the 6th of that month, the pencil attached to the float on his well suddenly gave a rise and fall of ⅜ in., and continued to oscillate for twenty minutes. After the first great throw of ⅜ in. the next vibrations were of ⅛ in., and they gradually diminished until they disappeared.

Symes carefully checked the time of this disturbance in his well and found it to synchronize exactly with an earthquake recorded by the Christchurch Milne seismograph, so that there is little doubt that the disturbance he noted was in reality caused by an earthquake.

9. CORRESPONDENCE BETWEEN RISES IN THE RIVER AVON AND THOSE OF THE WELLS NEAR BY.

It was not expected that fluctuations in the River Avon would have any effect on the water-level of the wells, but it was thought that the variations of level of the one might elucidate those of the other, and so a recorder was placed in position on the banks of the river, just above the Hospital, and continuous readings were taken for some months.

No relation between river and wells was observed. The river-level remains stationary for days on end, drawing a straight line on the graph, strikingly different from the agitated curves produced by the fluctuations in the adjacent wells. The only fluctuations observed are—(*a*) Those due to rain. The rise commences within half an hour or less of the beginning of a storm, and is in the neighbourhood of 7 in. per inch of rain if this falls within twelve hours. A rise of 7 in. in two hours has been recorded, but this was a torrential downpour of 0·7 in. (*b*) Those due to the river being cleared of weeds some distance below the recorder. On the 18th October, 1921, the river fell 4 in. in twenty-four hours, and

remained permanently lowered for some weeks. On that day weeds were being cut at Barbadoes Street over a mile below the recorder; and, although it hardly seemed likely that the influence of the cleaning would be felt so far up, no other explanation of a permanent depression of level suggests itself. (*c.*) Those caused by manipulation of the dam towards the headwaters of the stream. This sometimes causes the river at the Hospital to fall 2 in. or 3 in. in the course of an hour, and to recover its

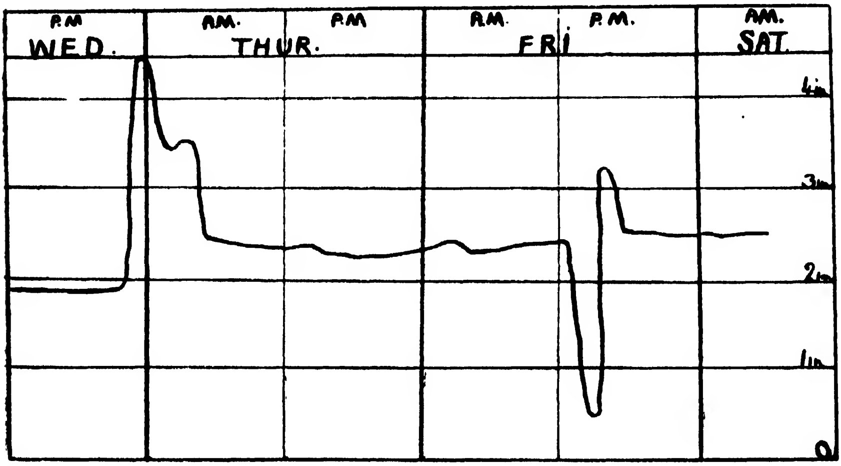

FIG. 4.—Fluctuations in level of River Avon: rain on Wednesday, dam-manipulation on Friday.

original level in the course of another hour. A sudden rise of about 2 in. is explained by the same cause. These changes usually take place at Saturday and Sunday midnights, and have no permanent effect on the river-level.

A fragment of a graph showing the rise due to 0·3 in. of rain, and also a combined fall, recovery, rise, and recession, due to dam-manipulation, is given in fig. 4.

C. THE CHEMICAL OBSERVATIONS.

It was thought that chemical analyses might show the source of supply of the Christchurch wells, and so samples were taken of water from the Waimakariri River; from a shallow non-flowing well at Harewood, about two miles from that river; from a 400 ft. well in Fletcher-Humphries' yard in Cathedral Square; and from the 344 ft. well at Lincoln College. The actual collection and analyses were done by Mr. M. J. Scott, of Lincoln College, for whose great care in the matter I am deeply grateful. Many of the individual trials were done in quadruplicate, and none in less than duplicate.

There is no suggestion in the figures that the Christchurch waters have a different source of origin from the Lincoln waters. The solids are obviously taken up during the passage of the water through the gravels of the plains, as the deep wells contain twice as much solid matter in solution as the river-water does. The figures will be seen to show a gradual increase in total solids the farther the well is from the river, and in general a similar gradual increase in each component of the total. This is quite consistent with the supposition that the wells sampled are all fed by percolation from the Waimakariri.

Parts per Million Dissolved Solids in various Filtered Waters.

—	Waimakariri River.	Harewood Well.	Christchurch Well.	Lincoln Well.
Total solids	42–42	46–48	80–82	82–86
After ignition	34–36	34–36	54–58	62–66
SiO_2	8·0	10·0	14·0	16·0
SO_3	2·7	2·7	3·5	3·0
CO_2	11·4	11·4	18·7	22·0
Cl	5·4	4·2	8·5	8·6
N_2O_5	0·08	0·3	1·6	0·4
FeO_3	0·6	2·0	0·5	0·25
CaO	14·0	12·0	20·0	22·0
MgO	1·5	2·8	4·3	2·9
NaO_2	3·0	3·0	1·6	5·7
K_2O	2·4	2·4	8·0	6·6
Hardness.				
Grains per gallon—				
Temporary	1·78	1·73	2·50	3·03
Permanent	0·15	0·26	0·75	0·23
Parts per million—				
Temporary	25·40	24·80	36·40	43·40
Permanent	2·10	3·70	10·80	3·20

On distributing the acids and bases after the method of Fresenius the following becomes the probable composition of these waters :—

Parts per Million in Solution.

	Waimakariri River.	Harewood Well.	Christchurch Well.	Lincoln Well.
SiO_2	8·0	10·0	14·0	16·0
Fe_2O_3	0·6	2·0*	0·5	0·25
K_2SO_4	4·4	4·4	7·6	6·5
NaCl	5·6	5·6	3·5	10·7
$CaCl_2$	3·1	1·2	10·4	3·4
$CaSO_4$	1·2	1·2	..	..
K_2CO_3	..	..	5·7	4·6
$Ca(NO_3)_2$	0·12	0·45	2·4	0·6
$CaCO_3$	21·4	19·0	27·5	36·1
$MgCO_3$	3·1	5·9	9·0	6·1
Total	47·5	49·7	80·6	84·25
Am. nitrogen	Not	0·05	0·03	0·25
Organic nitrogen	estimated	0·12	0·07	0·05
Dissolved O	7,492 cc.	5,310 cc.	5,460 cc.	6,442 cc.

* This well was fitted with a pump, through which the water was raised.

D. SUMMARY AND CONCLUSIONS.

Observations of the fluctuations of eight wells in and near Christchurch for periods ranging from one to fourteen years show that the wells rise with rain, but the amount of the rise, and the period that intervenes between the rain and the rise, depends greatly on the previous weather. While the wells are raised above normal level by rainfall, they are prevented from falling below normal by percolation from the River Waimakariri; and this is true not only of the town wells, but (contrary to my opinion in 1917) of the Lincoln wells also. The water-analyses are consistent with the thesis that both town and country wells are fed by percolation from the Waimakariri.

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Morainic Mounds on the Waimarino Plain near Ruapehu.

By Professor JAMES PARK, F.G.S., F.N.Z.Inst.

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Plate 78.

ON Section 14 of the Waimarino Military Reserve, eight miles as the crow flies from the summit of Ruapehu and about six miles from Waimarino, there are two groups of debris-hummocks that rise above the general level of the plain. They lie between the Whakapapanui and Tawhai Streams, both of which drain the north-west slopes of Ruapehu. One group, comprising scores of cones, extends from near the well-known Haunted Hut to the Rotoaira main road, while the other, a mere string of isolated mounds, begins at the main road near the Tawhai, and dots the plain to the north-west, ending about half a mile from the Whakapapaiti. After crossing the Whakapapanui, as one travels from Rotoaira towards Waimarino Railway-station the hummocks at once catch the eye, those to the right of the road near the Tawhai being especially prominent objects.

Generally the hummocks range from 20 ft. to 50 ft. high, but some are as low as 10 ft., and a few reach a height of 60 ft. Where they have been cut through along the road-line they are found to be composed of clayey matter and silts mingled with angular fragments of andesite ranging from small particles to blocks 6 ft. or more in greatest dimension. Most of the mounds have a circular or oval base. In places where two mounds unite the base is an elongated oval. Many of the mounds are cone-shaped. The Waimarino Plain, on which the hummocks stand, ranges from 2,600 ft. above sea-level at the lower end to 3,000 ft. along the foot of Ruapehu.

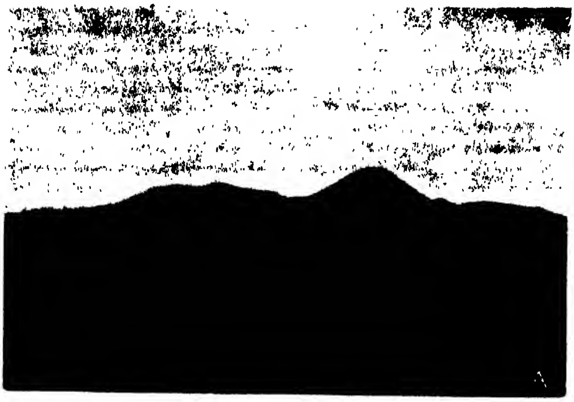


FIG. A.—Distant view of Tawhai mounds.

FIG. B.—Nearer view of Tawhai mounds.

FIG. C.—Excavation showing structure of mound on Waimarino-Rotoaira Road.

When we come to consider the origin of these debris-cones two explanations present themselves: they are either glacial, or the relics of a dissected flood-plain.

The Waimarino Plain is not a river or valley plain formed by ordinary fluviatile action, but an elevated platform evidently of fluvio-glacial origin built up around the base of Ruapehu. Where the plain is trenched by the consequent streams descending from the slopes of that mountain it is seen to be composed of clayey matter and semi-plastic silts in which are embedded angular rock-fragments in great abundance. In places there are present beds of well-worn gravels. The coarse, bouldery gravels exposed along the courses of the streams that now cross the plain are in the main, if not entirely, composed of re-sorted material.

The debris cones and mounds lying between the Haunted Hut and the Rotoaira Road are dotted irregularly over the plain, in places for a width of half a mile. They generally stand close to one another, and there is no evidence that drainage-channels or streams ever existed between them; on the contrary, undrained hollows lie between many of them.

I have already mentioned that the mounds are in part composed of large angular blocks of andesite. If the mounds were the residuals of stream-action one would expect to find the hollows between them piled with blocks derived from the excavated ground; but no such piles of blocks exist.

In general outline the Waimarino debris-cones resemble the morainic mounds that rise from the upper Waitaki Plain between Omarama and Lake Ohau. Frequent debris-cones have been described by Griffith Taylor* as occurring at McMurdo Sound and Granite Harbour, in South Victoria Land. I myself have seen similar glacial mounds in the Bow River region of Canada; also along the front of the Malaspina piedmont glacier, and at many places on the shores of Puget Sound.

Taylor made a close examination of some of the Antarctic debris-cones, and finally concluded that they were composed of material dropped from notches on the edge of the glacier front.

The crescent-shaped morainic ridges so often seen in Switzerland, New Zealand, and other glaciated regions were obviously terminal moraines piled up at periods when the rate of melting at the ice front equalled the rate of ice-flow. The morainic ridge to the west of the Waimarino Railway-station, described by me in 1909, evidently marked a one-time terminal front of the Pleistocene Waimarino glacier.† The Waimarino mounds were formed during the final retreat of the glacier, the material being piled up in ice-caves and notches along the edge of the ice-front.

The Waimarino glacier at one time filled the Mangahuia depression between Ruapehu and Hauhungatahi, and debouched over the plain, whence it was diverted by the high ridges to the west of Whakapapaiti towards the Retaruke country, over which much glacial detritus is spread. At the same time the Waiouru glacier, descending from the south-east flank of Ruapehu, sent a tongue of ice down the Hautapu Valley, scattering a trail of clay, silt, and rock-fragments as far south as Mangaweka, where many large erratic blocks of andesite derived from Ruapehu occur high up on the valley-slopes.

* GRIFFITH TAYLOR, The Physiography of the McMurdo and Granite Harbour Region. *British Antarctic ("Terra Nova") Expedition*, pp. 69–73. London, 1922.

† J. PARK, *Trans. N.Z. Inst.*, vol. 43, 1910, p. 580.

Granite Enclosures in a Quartz-biotite-diorite at Green Islets, Southland.

By Professor JAMES PARK, F.G.S., F.N.Z.Inst.

[*Read before the Otago Institute, 11th November, 1924; received by Editor, 19th December, 1924; issued separately, 31st March, 1926.*]

IN February, 1923, I visited Preservation Inlet and Chalky Sound. On the passage from the Bluff the boat, a small steam trawler, called at the Green Islets, a group of rocks which lie close to the mainland about twelve miles south-east of Preservation Inlet. At one place they enclose a small cove with a precarious boat-landing. Here the shore of the mainland is fringed between low-water and high-water marks by an uneven shelving water-worn platform of diorite.

A hundred yards to the east the diorite rises into a narrow ridge, the seaward end of which is detached from the mainland, forming a great natural arch, pierced by an archway 70 ft. high and 75 ft. wide at the floor-level. To the west the diorite is overlain by a coarse dioritic breccia, which here is the lowermost member of the Tertiary coal-bearing series.

A few yards to the right of the boat-landing the diorite encloses two masses of grey granite. The smaller is roughly circular in form and 4 ft. in diameter, while the larger, lying 4 yards to the east, is elliptical, and measures 10 ft. and 20 ft. in least and greatest diameters. These two occur on the crown of a flat hummock of rock, and are entirely surrounded by the diorite. In the larger mass the granite in parts grades into aplite.

GENERAL GEOLOGY.

Gneisses, crystalline schists, and limestones, followed by altered greywackes and slaty argillites that contain Cambrian and Ordovician graptolites, at one time occupied the whole of what is now the fiordland of Otago and Southland. In the late Palaeozoic these rocks were intruded by a batholith of diorite, which differentiates into granite in the south and into norite or gabbro and even serpentine around its northern periphery. This dioritic complex constitutes the Clinton River Intrusive Series described by me in 1921.*

As a consequence of subsequent uplift followed by subaerial denudation, the crystalline rocks have become broken up into many detached blocks, for the most part deeply involved among the intrusives. The largest remnant of the Cambrian and Ordovician crystalline rocks occurs between Preservation Inlet and Dusky Sound. The areas occupied by these rocks in the Princess Mountains and at Caswell and Doubtful Sounds are relatively small. All the great fiords have been carved in rocks belonging to the Clinton River dioritic intrusives, and not in the pre-Cambrian gneisses

* J. PARK, Geology and Mineral Resources of Western Southland, *N.Z. Geol. Surv. Bull.* 23 (n.s.), pp. 42–48; Wellington, 1921.

and crystalline schists as supposed by Hector and Hutton. The plutonic intrusion is believed to have taken place in the late Palaeozoic, and the general uplift towards the close of the Mesozoic.

GREEN ISLETS DIORITE.

The diorite is coarsely granular and typically hypidiomorphic. The dominant constituents of which it is composed are feldspars, quartz, and biotite; there is also some hornblende present. Petrologically the rock may be called quartz-biotite-diorite.

Well-twinned plagioclases are plentiful, and most of them are partially altered to sericite. Some large phenocrysts of anorthoclase with zonal structure are also present. Enclosed in the feldspars occur a few columns of zoisite.

Quartz is very abundant, filling the interstices. In the quartz occur minute microlites that may possibly be diopside. Some apatite and zircons are also present. There is much titanite between the biotite and hornblende, apparently secondary.

The biotite occurs in rounded piles and in six-sided forms. With the biotite is often associated a common green hornblende with vivid pleochroism—blue-green, brownish-olive, and greenish-brown.

GRANITIC ENCLOSURES.

The examples of granite examined in thin slice and submitted for analysis were collected from the larger of the two masses. The structure may be described as hypidiomorphic-granular. The rock is not fresh. The quartz and feldspars exhibit undulating extinction originating from intense pressure, but notwithstanding this the typical granite structure is perfectly preserved.

The constituent feldspars are orthoclase, often with traces of microcline structure, but seldom exhibiting the typical microcline cross-banding, and albite-oligoclase with basic oligoclase occurring as inclusions. There are also present some plagioclases with normal zoning and broad margins of albite. Albite as patches and in long bands occurs in the orthoclase. Sericite has developed in the feldspars most often in the middle of the plagioclases.

Biotite occurs as aggregates of small plates with irregular outlines. The margins are in places altered to chlorite. Rutile, titanite, and iron-ore are also present but not abundant. The mode of occurrence of the biotite shows that it developed from hornblende or some other mafic mineral.

The quartz is abundant, and, like the feldspars, shows strain effects arising from pressure. The rock is a biotite-granite.

The aplite possesses an evenly granular texture and an allotriomorphic structure. The dominant feldspar is albite. The orthoclase shows prominent microclinic cross-banding. There is also present a little feldspar with a micropegmatitic structure, and grains which show an intergrowth of plagioclase and vermicular quartz apparently replacing potash feldspar. Muscovite is plentiful. Both the quartz and feldspars show the strain effects usually associated with pressure. The rock is a phase of the granite, and may be called a granite-aplite.

As a consequence of the concentration of the basic feldspars and mafic minerals, large bodies of granite are known to grade into quartz-diorite

or even into norite and gabbro, but the occurrence of enclosures of granite in diorite is not so common. The transition from a quartz-biotite-diorite to a biotite-granite does not, after all, involve a violent amount of magmatic differentiation.

The dominance of the alcalic feldspars is what might be looked for in igneous rocks of a quartzose character. All three show a pyrogenetic relationship arising from progressive differentiation. The granite is clearly a phase of the diorite, and the aplite of the granite.

ANALYSES.

Through the courtesy of Mr. P. G. Morgan, M.A., F.G.S., Director of the Geological Survey, I obtained the following very complete analyses of the diorite, granite, and aplite, made in the Dominion Laboratory by Mr. F. T. Seelye, B.Sc. The molecular proportions are also given.

		Diorite.		Granite.		Aplite.	
		Anal.	M.P.	Anal.	M.P.	Anal.	M.P.
Silica	.. SiO_2	63·76	1·063	73·16	1·219	73·87	1·231
Alumina ..	.. Al_2O_3	15·49	0·152	13·74	0·134	14·67	0·144
Ferric oxide ..	.. Fe_2O_3	0·78	0·005	0·35	0·003	0·20	0·001
Ferrous oxide ..	.. FeO	4·60	0·064	1·48	0·021	0·42	0·006
Magnesia ..	.. MgO	1·61	0·040	0·31	0·008	None	..
Lime	.. CaO	3·15	0·056	1·60	0·029	0·82	0·014
Potash	.. K_2O	4·69	0·050	5·03	0·053	4·02	0·043
Soda	.. Na_2O	2·93	0·047	3·06	0·049	5·00	0·081
Water lost above 105° C.	.. H_2O	1·07	..	0·46	..	0·23	..
Water lost below 105° C.	.. H_2O	0·39	..	0·39	..	0·21	..
Carbon dioxide ..	.. CO_2	0·18	0·004	None	..	None	..
Titanium dioxide ..	.. TiO_2	0·80	0·010	0·23	0·003	0·03	..
Zirconium dioxide	.. ZrO_2	0·02	..	0·02	..	None	..
Phosphorus pentoxide	.. P_2O_5	0·37	0·003	0·17	0·001	0·15	0·001
Sulphur	.. S	None	..	None	..	None	..
Chromium trioxide	.. Cr_2O_3	None	..	None	..	None	..
Nickel oxide ..	.. NiO	Trace	..	None	..	None	..
Manganous oxide	.. MnO	0·10	0·001	0·02	..	0·33	0·004
Strontia	.. SrO	0·05	..	0·04	..	0·04	..
Baryta	.. BaO	0·21	..	0·18	..	0·04	..
		100·20	..	100·24	..	100·03	..

The carbon dioxide in the diorite is not present as calcite, as it is liberated only on heating with dilute hydrochloric acid.

Although in the course of the analysis no nickel was detected in the aplite, the joint-planes of the original specimen were coated with green stains which were found to contain nickel. Such surfaces were not included in the sample taken for analysis.

New Zealand Lepidoptera: Notes and Descriptions.

By ALFRED PHILPOTT, Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Institute, 14th November, 1924; received by Editor, 18th November, 1924; issued separately, 31st March, 1926.*]

NOCTUIDAE.

Ichneutica lindsayi n. sp.

♂. 43 mm. Head, palpi, and thorax bright brown. Antennae—stalk ochreous-white, pectinations brown, slightly longer than those of *I. dione* Huds. Abdomen and legs dull brown. Forewings—costa almost straight, apex subacute, termen straight, oblique, rounded beneath; brown, densely mixed with ochreous: veins strongly marked with blackish-fuscous: a broad fawn-coloured stripe beneath costa from base to reniform with which it coalesces; above this stripe and for some distance beyond its apex is a considerable irroration of whitish; a streak of the same colour, margined with blackish fuscous beneath this, apically obtuse, directed obliquely towards tornus and reaching nearly to $\frac{2}{3}$; dorsum narrowly fawn-coloured: fringes pale fawn. Hindwings fuscous-grey: fringes pale fawn.

In one specimen basal portion of costal stripe is obsolete, and in this example there is also a faint very oblique subterminal line.

A very handsome and distinct species. I have named it in honour of Mr. S. Lindsay, to whose kindness I am indebted for the opportunity of describing this and several other new forms recently discovered by him.

Hunter Mountains (near Lake Manapouri), in January. Several examples taken by Messrs. S. Lindsay and C. E. Clarke. Holotype (♂) in coll. S. Lindsay.

Aletia parmata n. sp.

♀. 32 mm. Head and thorax grey. Palpi grey, terminal segment rather long, thin, blunt-pointed. Antennae brown, grey basally. Abdomen brownish-grey. Legs grey mixed with brown, tarsi narrowly annulated with white. Forewings moderate, costa almost straight, apex subacute, termen straight, oblique, slightly sinuate on lower third; grey, rather darker between stigmata; veins obscurely and interruptedly marked with black; orbicular large, round, whitish, incompletely black-margined; claviform indicated by black margin only; reniform broad, whitish, interruptedly black-margined; some obscure dark-brown spots on costa between $\frac{1}{3}$ and apex; a series of indistinct black dots round termen: fringes brown mixed with white. Hindwings greyish-fuscous: fringes whitish-grey.

Differs from *A. longstaffi* (Howes) in the shorter labial palps, and from *A. obsecrata* Meyr. in the lighter colouring.

Mount Grey, Canterbury, in February. Another of Mr. Lindsay's captures. Holotype (♀) in the discoverer's collection. What appears to be the male of the species was captured in the same locality but at a higher elevation; as, however, it is not in very good condition I have not made it the allotype. The colour of this specimen is darker, and stigmata are almost obsolete; antennae are clothed beneath with extremely short ciliations, about $\frac{1}{4}$.

Ophiusa melicerte Drury, *Ill. Exot. Ins.*, vol. 1, p. 46, pl. 23, fig. 1.

The first known occurrence of this Australian moth in New Zealand was in the autumn of 1870, when one was captured by Mr. W. T. L. Travers in his greenhouse at Wellington. In 1877 Mr. R. Fereday described this specimen as a new species under the name of *Catocala traversii* (*Trans. N.Z. Inst.*, vol. 9, p. 457). In 1904 several were taken, and others seen, at Titahi Bay, Wellington, by Mr. C. O'Connor. This was in March; and in the same year Mr. G. V. Hudson recorded a single specimen from Motueka, Nelson, taken in February or March. Waitomo and Orepuki are mentioned by Mr. G. M. Thomson (*Naturalization of Animals and Plants in New Zealand*, p. 303) as localities for other captures, but I have not been able to secure definite particulars of these. I have now to record the occurrence of the species in Nelson, a worn example having been picked up in the street by some boys on the 27th March of this year and brought to the Cawthron Institute. It will be noticed that all the occurrences have been in autumn. In view of the very erratic nature of the records, it seems unlikely that the species is established in New Zealand; occasional accidentally introduced specimens would with more probability account for the facts. The comparative abundance of the species near Wellington in 1904 may have been the result of a single batch of eggs, the resultant moths or their progeny failing to survive the following winter.

Ophideres materna (L.), *Syst. Nat.*, ed. 10, vol. 1, p. 2, pl. 40.

A very fine specimen of this handsome Australian moth was taken by Mrs. T. W. Taylor, of Nelson, on the 10th April, 1924. It was attracted to a lighted window, and was in such perfect condition that it could have emerged from the pupa only a short time before. Its captor generously presented it to the Cawthron Institute. Mr. Hudson has recorded a specimen taken by Mr. Cook at Makara, near Wellington, in May, 1906; Mr. W. G. Howes took one at Dunedin in March, 1907; and I learn from Mr. Hudson that a third was secured at Akaroa Lighthouse in October, 1917. These are all the known occurrences. The caterpillar feeds on bananas, a habit probably accounting for the occasional appearance of the moth in this country.

Hydriomenidae.

Chloroclystis fumipalpata (Feld.), *Reise der Nov.*, pl. 31, fig. 33.

Chloroclystis maculata Huds., *N.Z. Moths and Butterflies*, p. 44, pl. 6, fig. 18, 1898.

Mr. Hudson concurs in the above correction.

Xanthorhoe dissimilis (Philp.).

Venusia dissimilis Philp., *Trans. N.Z. Inst.*, vol. 46, p. 118, 1914.

I take this opportunity of making the above generic correction.

Xanthorhoe praefectata (Walk.), *Cat.*, 781. (Fig. 1.)

Dr. A. Jefferis Turner has pointed out to me that in this species the characters of the mouth-parts and head are similar to those of *Venusia*; in his opinion the species ought to be removed to that genus. Dr. Turner's observation is quite correct; and as far as the characters in question are concerned there could be no objection to *praefectata* being placed under

Venusia. The areole, however, is double, while the simple areole is an essential character of that genus. It appears to the writer that a new genus is required for the reception of *X. praefectata*, such genus including

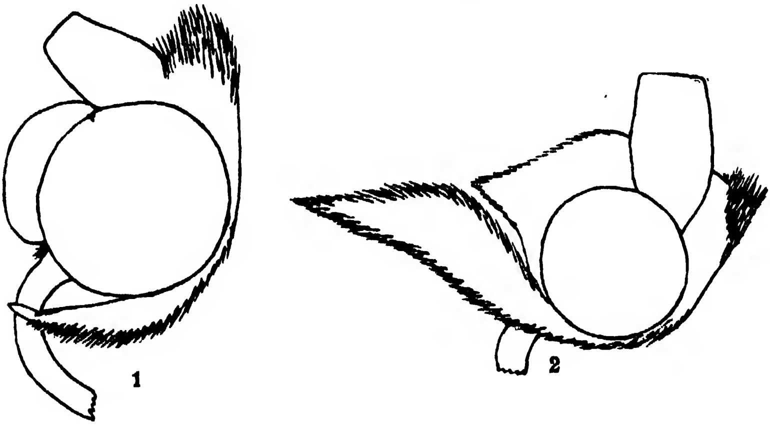


FIG. 1.—*Xanthorhoe praefectata* (Walk.): lateral view of head.
FIG. 2.—*Xanthorhoe aegrota* (Butl.): lateral view of head.

also *X. chlorias* Meyr. and *X. pseudostinaria* Huds., these species having exactly similar characters to those of *praefectata*. Figures of the head of *X. praefectata* (Walk.) and *X. aegrota* (Butl.) are given to illustrate the difference of the parts.

SELIDOSEMIDAE.

Selidosema fluminea n. sp.

♂ ♀. 34–38 mm. Head brownish-ochreous. Palpi brown. Antennae strongly bipectinated, five or six apical segments simple, stalk ochreous, pectinations fuscous. Thorax greyish-fuscous. Abdomen ochreous, slightly mixed with brown. Legs ochreous, sprinkled with fuscous, and with tibiae and tarsi broadly annulated with dark fuscous. Forewings triangular, costa moderately and evenly arched, apex obtuse, termen rounded, oblique; dark brownish-fuscous, olive-tinted and strigulated with ochreous; first line from ¼ costa to ⅓ dorsum, prominent, curved or obtusely angulated at middle, white; posterior to the lower half of this line is a large ochreous patch, sometimes extending across to second line; second line forming a broad hardly-curved white band, more or less tinted, except on inner edge, with ochreous, and with some fuscous strigulation, inner edge very irregular, outer edge entire; subterminal line thin, irregularly dentate, more or less interrupted at middle, white; a series of linear black dots round termen: fringes ochreous mixed with fuscous. Hindwings whitish-ochreous faintly sprinkled with fuscous and with a fuscous discal dot; an interrupted blackish line round termen: fringes pale ochreous.

Structurally separated from *S. leucelaea* Meyr. by the much longer antennal pectinations, which are not quite so long as those of *S. productata* (Walk.).

Flora River, on the track to Mount Arthur Tableland. Mr. S. Lindsay and the writer found the males of this handsome species plentiful at the blossom of *Olearia* and *Gaya* in January. The elevation would be about 3,250 ft. Only one female was secured; this sex agrees well with the

male, but is less fuscous and has a narrower second line. Holotype (♂) and a series of paratypes in coll. Cawthron Institute; allotype (♀) in coll. S. Lindsay.

Crambidae.

Orocrambus caesius n. sp.

♂ ♀. 25–27 mm. Head, palpi, and thorax fuscous-black densely sprinkled with white and pale ochreous; a small golden spot at bases of maxillary palpi above. Antennae greyish-fuscous. Abdomen dark fuscous densely mixed with ochreous-white. Legs whitish-ochreous, slightly infuscated, and tarsi annulated with fuscous. Forewings moderate, suboblong, costa almost straight, subsinuate at middle, apex rectangular, termen not oblique, rounded beneath; fuscous-black densely irrorated with white; on obscure blackish basal line; first line at $\frac{1}{4}$, whitish, margined posteriorly with blackish, strongly indented at middle; orbicular obscure, taking the form of a black dot or a black ring filled with whitish; claviform obsolete; reniform 8-shaped, wholly blackish- or whitish-centred; second line at $\frac{3}{4}$, obscure, irregular, whitish, anteriorly blackish-margined, more prominent in female; a very obscure whitish subterminal shade touching second line above middle: fringes ochreous mixed with fuscous and with a dark-fuscous basal line. Hindwings shining fuscous: fringes ochreous with a fuscous basal line.

Superficially somewhat like *Tauroscopa glaucophanes* Meyr.

Gordon's Pyramid (5,000 ft.) and Mount Arthur Tableland (4,500 ft.), in January. Two of each sex taken. Holotype (♂), allotype (♀)), and one paratype in coll. Cawthron Institute.

Crambus scitulus n. sp.

♂. 33 mm. Head white. anterior median portion brown, collar dark bronzy-brown except median white stripe. Palpi moderate, brown, white above and at base beneath. Antennae dark fuscous, basal segment white except on broad internal area. Thorax dark bronzy-brown with broad median white stripe. Abdomen ochreous-white. Legs whitish-ochreous, median pair somewhat infuscated and anterior tibiae and tarsi wholly bronzy-brown. Forewings rather broad, hardly dilated posteriorly, costa almost straight, subsinuate at middle, apex obtuse, termen rounded, oblique; dark bronzy-brown, becoming paler towards apical area; a thin subcostal white line from base to beyond middle; a suffused whitish area beneath costa at $\frac{3}{4}$; a prominent median white stripe from base to termen, slightly sinuate at middle and somewhat arched on posterior $\frac{1}{3}$; a whitish streak beneath first cubitus; dorsum rather broadly white but extreme edge from about $\frac{1}{2}$ brown; veins on terminal area irregularly marked with black: fringes brown, obscurely barred with white. Hindwings shining ochreous-whitish tinged with brown: fringes ochreous-whitish.

Somewhat resembling *C. callirrhous* Meyr.

Mount Arthur, in January. One of Mr. S. Lindsay's discoveries; he secured a single male at an elevation of about 4,000 ft. Holotype (♂) in coll. S. Lindsay.

Crambus vulgaris Butl., *Proc. Zool. Soc. Lond.* (1877), p. 400, pl. 43, fig. 7.

Crambus tuhualis Meyr. (*nec* Felder), *Trans. N.Z. Inst.*, vol. 15, p. 28, 1883.

Crambus tuhualis Feld., *Reise der Nov.*, *Lepidoptera*, pl. 137, fig. 18, 1875.
Crambus thrincodes Meyr., *Trans. N.Z. Inst.*, vol. 43, p. 61, 1911.

A recent study of Felder's plates has resulted in the above corrections, in which Mr. Meyrick agrees.

PYRAUSTIDAE.

Scoparia cinefacta n. sp.

♂ ♀. 19–20 mm. Head grey mixed with brown. Thorax pale bluish-grey. Palpi moderate, grey above, laterally brown, at base beneath whitish. Antennae fuscous, minutely ciliated. Abdomen grey mixed with ochreous. Legs fuscous-grey. Forewings moderate, costa almost straight, subsinuate at middle, apex obtuse, termen hardly oblique, rounded beneath; pale bluish-grey; orbicular represented by a fuscous dot, farther distad than usual; reniform X-shaped, fuscous-black; second line very obscurely indicated by paler transverse area, angled sharply inward opposite reniform, preceded and followed by a margining of obscure linear fuscous dashes: fringes grey with darker basal shade. Hindwings fuscous-grey: fringes as in forewings.

The bluish ground-colour recalls *S. asaleuta* Meyr., but in *S. cinefacta* the forewings are broader and the hindwings much darker in colour.

Gordon's Pyramid, in January. Three examples taken at about 4,500 ft. Holotype (♂), allotype (♀), and a paratype in coll. Cawthron Institute.

TORTRICIDAE.

Cnephasia paterna n. sp.

♂. 21 mm. Head and palpi fuscous mingled with reddish. Antennae dark fuscous, annulated with whitish, swollen at joints, ciliations $3\frac{1}{2}$. Thorax leaden-fuscous. Abdomen greyish-fuscous. Legs ochreous-white mixed with fuscous, anterior pair fuscous, tarsi narrowly annulated with white. Forewings elongate-triangular, costa slightly arched at base, thence straight, apex round-pointed, termen straight, strongly oblique; leaden-fuscous, densely strigulated with blackish and with scattered reddish scales; costal fold small, about $\frac{1}{4}$; a strong outwardly-oblique fascia from costa at apex of fold, yellow mixed with red; a similarly-coloured fascia, preceded by numerous red scales, from costa before middle, outwardly oblique, parallel-sided, reaching about $\frac{1}{3}$ across wing; a yellow-and-red spot on costa before apex; some indefinite white marks on apical area: fringes grey with a reddish basal line. Hindwings grey strigulated with fuscous: fringes whitish-grey.

Very distinct and interesting.

Little River, Canterbury. The unique example was taken by Mr. S. Lindsay in March. Type in coll. S. Lindsay.

OECOPHORIDAE.

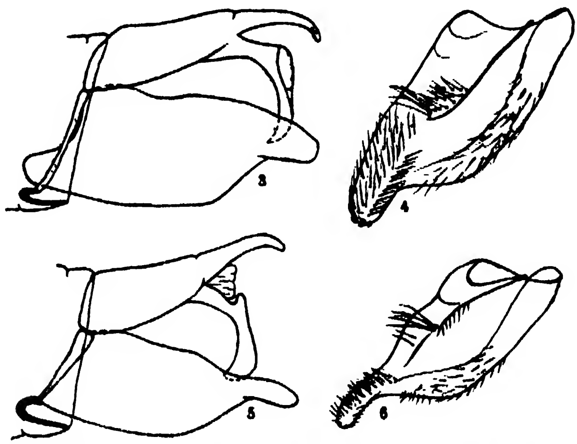
Borkhausenia affinis n. sp. (Figs. 3, 4.)

♂. 13–14 mm. Head, palpi, and thorax bronzy-brown mixed with grey. Antennae brown, narrowly annulated with ochreous, ciliations in male $\frac{3}{4}$. Abdomen bronzy-brown. Legs brown mixed with grey. Forewings elongate, narrow, not posteriorly dilated, costa slightly arched, sinuate at middle, apex pointed, termen extremely oblique; bronzy-brown; space below fold from near base almost to tornus occupied by a clear yellow stripe; a few yellow scales indicating post-median and pre-apical fasciae:

fringes grey with scattered fuscous and yellow points. Hindwings broadly lanceolate; bronzy-fuscous: fringes fuscous with darker basal shade.

Belongs to the *siderodeta* group; the practical absence of fasciae and the dorsal yellow stripe are good distinguishing characters.

Nelson in December, and Dun Mountain in January. A single male from each locality. Holotype (♂) and a paratype in coll. Cawthron Institute.



FIGS. 3, 4.—*Borkhausenia affinis* n. sp. 3, male genitalia, lateral view: 4, clasper, from within.
FIGS. 5, 6.—*Borkhausenia terrena* n. sp. 5, male genitalia, lateral view: 6, clasper, from within.

Borkhausenia terrena n. sp. (Figs. 5, 6.)

♂. 13-15 mm. Head, palpi, and thorax greyish-brown. Antennae greyish-brown spotted with whitish. Abdomen brown, segmental divisions lead-coloured. Legs greyish-brown, posterior pair mixed with whitish. Forewings elongate, not posteriorly dilated, costa almost straight, sub-sinuate at middle, apex round-pointed, termen very oblique; greyish-brown, rather darker apically: fringes concolorous with wings. Hindwings and fringes fuscous-brown.

Near *B. melanamma* Meyr. but with a different contour of the forewing and complete absence of markings.

Queenstown, in December. Eight males secured on the lower slopes of Ben Lomond. Type in coll. A. Philpott.

Borkhausenia vestita n. sp.

♂. 18 mm. Head pale ochreous. Palpi pale ochreous, fuscous beneath, except at base and apex of second segment. Antennae dark fuscous, ciliations in whorls at joints, 4. Thorax dark ochreous, shoulder bronzy-brown. Abdomen bronzy-fuscous, segmental divisions leaden-white. Legs ochreous, more or less infuscated, anterior pair dark brown above. Forewings elongate, costa strongly arched, apex broadly rounded, termen rounded, very oblique; bronzy-brown, more ochreous apically; a broad ochreous-white stripe from base to tornus with a black spot resting on its lower edge at ⅓; a blackish spot above this in the dark costal area; a rather large

black discal spot at $\frac{2}{3}$: fringes dull-brownish. Hindwings dark fuscous : fringes fuscous with darker basal line.

Appears to belong to the *robiginosa* group, but differs from all its relatives in the submedian pale stripe.

Hunter Mountains (Manapouri). Taken by Mr. S. Lindsay in January. Type in coll. S. Lindsay.

Euchersadaula tristis n. sp. (Figs. 9, 10.)

♂. 15–17 mm. Head brownish, tinged with pink. Palpi brown, mixed with whitish within. Antennae brown, ciliations over 1. Thorax bronzy-brown. Abdomen pale bronzy-brown, segmental divisions whitish. Legs bronzy-brown, tarsi annulated with whitish-ochreous. Forewings elongate, costa moderately arched, apex obtuse, termen almost straight, oblique ; bronzy-brown, strongly tinged with pink, especially on apical half, and with scattered scales and spots of fuscous-black ; markings fuscous-black ; an obscure striga from costa at $\frac{1}{4}$, outwardly oblique to fold and enclosing first discal and plical spots ; a similar striga from costa beyond middle to tornus, enclosing second discal spot ; a faint subterminal striga, sharply angled inwards at middle ; some scattered scales and spots ; the strigae may be ferruginous, and sometimes there is considerable admixture of whitish-ochreous : fringes leaden-fuscous tinged with pink. Hindwings fuscous, darker apically : fringes greyish-fuscous with darker basal line.

Not easily distinguished from *E. lathriopa* (Meyr.), but a rather larger and broader-winged form.

Nelson, from sea-level to 3,000 ft. Fairly common in forest country. Holotype (♂) and a series of paratypes in coll. Cawthron Institute.

Leptocroca scholaea (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 35, 1884.

Mr. Meyrick informs me that this species and *asphaltis* Meyr., formerly placed in *Borkhausenia*, belong to the above genus. I have also two unnamed species (described below) which belong here. These New Zealand species of *Leptocroca* are very obscure insects, and it would not be a matter for surprise if several others have so far been overlooked. I give the diagnosis of the genus as it appears in Meyrick's revision of the Oecophoridae in the *Genera Insectorum* :—

" *Leptocroca* Meyrick, *Proc. Linn. Soc. N. S. Wales*, vol. 7, p. 425, 1883. Type : *L. sanguinolenta* Meyrick.

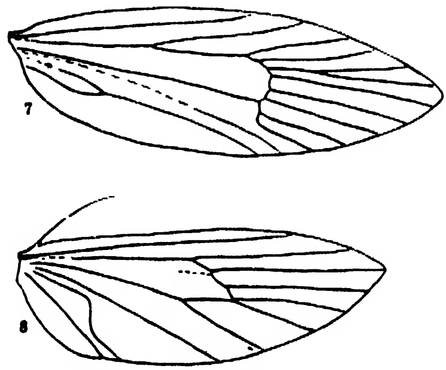
" *Characters.*—Head with appressed scales, side-tufts roughly spreading ; ocelli posterior ; tongue developed. Antennae $\frac{4}{5}$, in male moderately or strongly ciliated ($\frac{1}{2}$), basal joint elongate, with pecten. Labial palpi long or very long, recurved, second joint reaching or exceeding base of antennae, thickened with appressed or loose scales, terminal joint as long as second or shorter, moderate, acute. Maxillary palpi very short, filiform, appressed to tongue. Posterior tibiae clothed with hairs above. Forewings with 1*b* furcate, 2 and 3 connate or stalked from angle, 7 and 8 stalked, 7 to costa, 11 from middle. Hindwings 1, elongate-ovate, cilia $\frac{1}{3}-\frac{1}{2}$, 3 and 4 connate, 5–7 parallel."

Fifteen species are known from Australia, and three from Tasmania.

Leptocroca vacua n. sp.

♂ ♀. 19–22 mm. Head and thorax ashy-brown. Palpi greyish, more or less infuscate. Antennae greyish-brown, in male shortly ciliated, under 1.

Abdomen golden-brown, segmental divisions greyish-white. Legs ochreous-grey, more or less infuscated. Forewings elongate, costa strongly arched. apex obtuse, termen rounded, very oblique; ashy brown sprinkled with ferruginous; markings dull ferruginous; stigmata obscure, plical obliquely



FIGS. 7, 8.—*Leptocroca vacua* n. sp. 7, forewing; 8, hindwing.

beyond first discal; a subterminal line, strongly bent outwards to middle, thence strongly inwards, usually faint and frequently obsolete: fringes concolorous with wing. Hindwings shining grey, darker apically: fringes grey with darker basal line.

A very obscure species, with the forewings less ferruginous than *L. scholaea* (Meyr.).

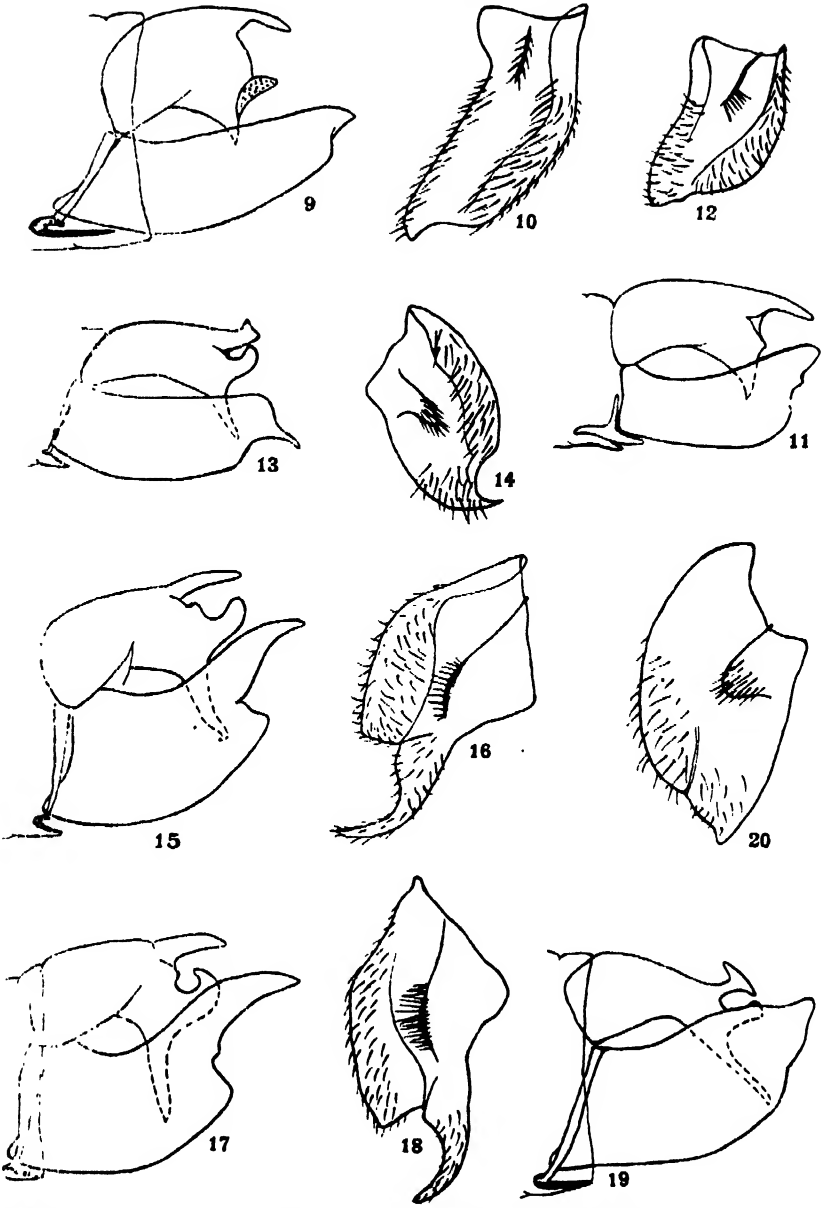
Nelson, from October to January. Fairly common at low elevations. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

Leptocroca variabilis n. sp. (Figs. 17, 18.)

♂. 16–19 mm. Head and palpi fuscous mixed with ochreous. Antennae fuscous, ciliations in male 1. Thorax bronzy-fuscous. Abdomen ochreous, segmental divisions whitish. Legs fuscous, posterior tarsi annulated with ochreous. Forewings elongate, costa moderately arched, apex obtuse, termen rounded, oblique; greyish-fuscous mixed with whitish and ferruginous scales; stigmata brownish-black, plical below first discal, margined anteriorly with white; second discal irregularly quadrilateral; a suffused fuscous patch on costa above first discal and a similar one on middle of costa; a very obscure irregular curved subterminal fascia: fringes whitish mixed with fuscous and ferruginous. Hindwings greyish-fuscous, more bronzy apically: fringes fuscous-grey with obscure darker basal and median bands. In some examples the forewings are densely irrorated with ochreous-white, and in such specimens the stigmata are large and prominent; the paler colour also extends to the head and thorax.

Somewhat resembling *L. scholaea* (Meyr.), but a smaller and greyer form.

Six males from Cobb Valley in December, and another in the same month from Mount Arthur Tableland at about 4,500 ft. Holotype (♂) and a series of paratypes in coll. Cawthron Institute.



FIGS. 9, 10.—*Euchersadaula tristis* n. sp. 9, male genitalia, lateral view; 10, clasper, from within.
FIGS. 11, 12.—*Euchersadaula lathriopa* (Meyr.). 11, male genitalia, lateral view; 12, clasper, from within.
FIGS. 13, 14.—*Leptocroca scholaea* (Meyr.). 13, male genitalia, lateral view; 14, clasper, from within.
FIGS. 15, 16.—*Leptocroca asphaltis* (Meyr.). 15, male genitalia, lateral view; 16, clasper, from within.
FIGS. 17, 18.—*Leptocroca variabilis* n. sp. 17, male genitalia, lateral view; 18, clasper, from within.
FIGS. 19, 20.—*Leptocroca vacua* n. sp. 19, male genitalia, lateral view; 20, clasper, from within.

Izatha heroica n. sp.

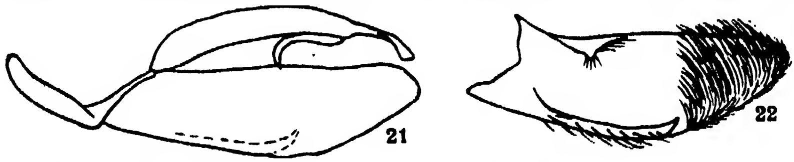
♀. 32 mm. Head and thorax white. Palpi white, basal half of second segment externally black, also an obscure blackish ring near apex, terminal segment with a sprinkling of black scales forming an indefinite ring at tooth. Antennae fuscous mixed with white, basal segment paler. Abdomen ochreous-whitish, apical segment brown. Legs grey-whitish, tarsi banded with dark fuscous. Forewings elongate, broad, costa well arched, apex obtuse, termen rounded, oblique; white, densely irrorated with pale fuscous: seven blackish spots on costa, first at base, second at $\frac{1}{4}$, third at $\frac{1}{2}$, seventh at apex, and remaining three at equal distances between third and seventh: a blackish spot in disc obliquely beyond second costal, and a linear blackish mark on fold beneath this; three blackish spots forming a triangle in disc at about middle, the most apical obliquely beyond third costal; a less clearly defined spot towards apex; a series of blackish spots on termen: fringes white. Hindwings grey-whitish with an undefined dark discal spot: fringes grey-whitish.

A very distinct form, larger and without the dark fasciae of the other white species.

Flora River, in January. A single female taken in bush at about 3,250 ft. Type in coll. Cawthron Institute.

Barea ambigua n. sp.

♂. 19–20 mm. Head and thorax greyish-brown. Palpi greyish-white, densely mixed with dark fuscous. Antennae greyish-brown, closely annulated with fuscous, ciliations very short. Abdomen greyish-brown, median dorsal area more or less ochreous. Legs ochreous-grey-whitish, strongly infuscated, tarsi broadly annulated with dark fuscous. Forewings—costa moderately arched, apex rounded, termen faintly sinuate, strongly



Figs. 21, 22.—*Barea ambigua* n. sp. 21, male genitalia, lateral view; 22, clasper, from within.

oblique; dull greyish-brown irrorated with dark fuscous; markings dark fuscous; an irregular blotch on costa and dorsum at base; an irregular transverse fascia at $\frac{1}{3}$, obsolete on costa and dorsum; a large irregularly pear-shaped spot at $\frac{2}{3}$; some obscure dashes distad of this spot; a series of dots round termen: fringes concolorous with wing. Hindwings grey tinged with fuscous: fringes grey with obscure darker lines.

An obscure but distinct species, best distinguished by the peculiar spot in disc at $\frac{2}{3}$.

Horseshoe Lake, Christchurch. Four males taken by Mr. W. Heighway in November and December. Holotype (♂) and two paratypes in coll. W. Heighway.

Proteodes clarkei n. sp.

♂. 24 mm. Head light yellow. Palpi—second segment ferruginous except at apex which is yellow, terminal segment yellow. Antennae fuscous, closely annulated with darker, basal segment ferruginous, ciliations almost 1. Thorax yellow, tegulae and a broad median stripe ferruginous. Abdomen ochreous-white. Legs ochreous-white, anterior pair mixed with

ferruginous. Forewings elongate-trianglar, costa moderately arched, apex rounded, termen slightly rounded, oblique; ferruginous; a broad stripe of yellow occupying median portion of wing, sharply separated in a straight line from costal ferruginous area, and suffusedly margined with ferruginous along dorsum and termen; a prominent blackish-ferruginous dot in disc at $\frac{2}{3}$, broadly margined anteriorly with metallic white: fringes ferruginous. Hindwings shining white tinged with ochreous: fringes pink.

The colour and markings of this handsome species are very similar to those of the genus *Gelophaula* of the family Tortricidae.

Hunter Mountains (Manapouri). Several taken by Messrs. Clarke and Lindsay at about 4,000 ft. in January. Type in coll. S. Lindsay.

GLYPHIPTERYGIDAE.

Hierodoris (?) insignis n. sp.

♀. 12 mm. Head and thorax dark bronzy-purplish-fuscous. Palpi and antennae dark brownish-fuscous. Abdomen dark purplish-brown. Legs dark fuscous, tibiae and tarsi obscurely annulated with greyish-white. Forewings moderate, costa slightly arched, apex rounded, termen extremely oblique; white, densely irrorated with leaden-grey; along dorsum wholly leaden-grey; markings purplish-black; a nearly straight, broad, subbasal fascia, an outwardly-oblique, broad, irregular fascia from costa at $\frac{1}{3}$, reaching to fold; a large round spot in disc at $\frac{2}{3}$, almost touching a semi-oval spot on costa; a fuscous suffusion along termen: fringes fuscous-grey with some white scales. Hindwings under 1, trapezoidal; purplish-fuscous: fringes fuscous.

A very distinct form. The markings give the species a striking resemblance to a small Tortricid. I have placed this interesting species in *Hierodoris* provisionally, but the maxillary palpi are present though small. Further material is necessary in order to fix the generic position with certainty.

Mount Arthur Tableland, in January. The unique example was captured by Mr. S. Lindsay at an elevation of about 4,000 ft. Type in coll. S. Lindsay.

Simaethis nivescens n. sp.

♂♀. 16–17 mm. Head and palpi brown densely sprinkled with white; second segment of palpi with strong but longitudinally-narrow scale-tuft. Antennae blackish annulated with white, ciliations in male $1\frac{1}{3}$. Thorax bronzy-brown, tegulae spotted with white. Abdomen bronzy-brown, segmental divisions white. Legs brown, densely sprinkled with white. Forewings moderate, costa slightly arched, apex rounded, termen slightly rounded, little oblique; bronzy-brown; basal $\frac{2}{3}$ sprinkled with white scales which tend to form one or two bands; a white spot on costa at $\frac{2}{3}$ giving rise to a white line which follows an outwardly-oblique course to near middle of wing, thence bending sharply inwardly to above dorsum to which it recurves, in male this line is absorbed in subterminal band of white scales; preceding this line is a broad band almost free of white scales except those forming the discal spot; a broad subterminal band of white scales, touching second line at middle: fringes white, with broad blackish basal band and a similar but paler apical band. Hindwings fuscous; a white fascia round tornus, thence dividing into two and extending to middle of termen, in male this fascia is represented by only a few scales: fringes as in forewings.

Superficially nearest to *S. combinatana* Walk., but the structural difference in the palpi at once distinguishes it.

Mount Arthur Tableland, in January; a single female taken among rough herbage at about 4,500 ft. Gordon's Pyramid, a single male, also found in January. Holotype (♂) and allotype (♀) in coll. Cawthron Institute.

TINEIDAE.

Crypsitricha generosa n. sp.

♀. 17 mm. Head white, ochreous-tinged. Labial palpi dark fuscous, apical half of terminal segment ochreous-white; maxillary palpi dark fuscous. Antennae fuscous. Thorax ochreous, tegulae fuscous at base. Abdomen ochreous-white. Legs ochreous-white, middle and anterior pairs strongly infuscated, the tarsi narrowly annulated with ochreous. Forewings elongate, narrow, not dilated, costa slightly arched, apex pointed, termen rounded, very oblique; white mixed with ochreous; a blackish-fuscous stripe along costa from base to beyond $\frac{3}{4}$, gradually dilated to $\frac{1}{2}$, where it reaches about half across wing, beyond this narrowed by the intrusion of a whitish discal patch, from base to $\frac{1}{2}$ margined beneath with bright ochreous; apex ochreous: fringes white mixed with ochreous. Hindwing and fringes ochreous-white, costal fringes fuscous tinged.

A well-marked species not closely resembling any other member of the genus.

Hunter Mountains (Manapouri). A single female taken by Mr. S. Lindsay in December. Type in coll. S. Lindsay.

Archyala opulenta n. sp.

♂. 17–19 mm. Head and palpi ochreous mixed with fuscous. Antennae fuscous. Thorax dark fuscous mixed with ochreous. Abdomen dark greyish-fuscous. Legs fuscous mixed with ochreous. Forewings elongate, costa strongly arched, apex round-pointed, termen rounded, very oblique; ochreous; numerous dark purplish-fuscous outwardly-oblique interrupted strigae, most prominent on costa; a broader and more continuous one from $\frac{2}{3}$ costa to $\frac{3}{4}$ dorsum; a series of ochreous spots round termen: fringes fuscous mixed with ochreous. Hindwings fuscous with purplish-violet reflections: fringes dark fuscous.

A handsome species; the ochreous ground-colour of the forewings is a good distinguishing character.

Upper Maitai, in November. Two males taken in bush by Mr. E. S. Gourlay. Type and paratype in coll. Cawthron Institute.

Sagephora jocularis n. sp.

♂. 9 mm. Head white tinged with brown. Palpi fuscous, apex of second segment and terminal segment white. Antennae ochreous, annulated with fuscous. Thorax fuscous, a lateral stripe and tegulae whitish-ochreous. Abdomen fuscous. Legs greyish-fuscous. Forewings elongate, costa moderately arched, apex rounded, termen very oblique; ochreous mixed with white; a broad, fuscous-brown stripe along costa from base to $\frac{4}{5}$, strongly dilated on its apical half where it is margined beneath with white; a fuscous-brown stripe on dorsum from base to $\frac{1}{2}$; beyond this to tornus the fuscous is mixed with ochreous-white; apical fourth chiefly fuscous-brown but with some mixture of ochreous and white; a thin ochreous and white line along termen: fringes greyish-fuscous with interrupted black basal line. Hindwings and fringes greyish-fuscous.

Nearest to *S. phortegella* Meyr., but a smaller and darker insect.

Tisbury (Southland), in January; a single male in bush. Mr. S. Lindsay has a specimen taken at Purau, in October. Type in coll. A. Philpott.

In concluding, I should like to express my gratitude to Mr. E. Meyrick, Dr. A. J. Turner, and Mr. G. V. Hudson for much assistance and counsel. I have also much pleasure in acknowledging the kind help of Messrs. S. Lindsay, C. E. Clarke, and W. Heighway, who have provided me with much of the material dealt with.

List of New Zealand Species of *Borkhausenia* (Oecophoridae: Lepidoptera), including New Species.

By ALFRED PHILPOTT, Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 11th June, 1924; received by Editor, 16th June, 1924; issued separately, 31st March, 1926.*]

IT is proposed in the following paper to list all the species of *Borkhausenia* known to occur in New Zealand, and to give figures of the male genitalia in all instances where the material has been available. The genus is one of the largest in New Zealand, being surpassed only by *Scoparia*. Including the new forms here described, the total number of species so far discovered amounts to sixty. Many of the forms are obscure, and not easily separated by superficial characters; the study of the male genitalia, however, in great part removes this difficulty.

For the measure of completeness to which I have been able to bring the paper I have to thank several lepidopterists who have freely helped me by supplying material which was lacking in my own collection and that of the Cawthron Institute. To Mr. G. V. Hudson my thanks are especially due, and I have also received valued assistance from Messrs. C. E. Clarke, C. C. Fenwick, E. S. Gourlay, and S. Lindsay. To Messrs. R. Speight and G. Archey, Curator and late Assistant Curator of the Canterbury Museum, I am indebted for the opportunity of examining the members of the genus represented in the Fereday collection. Dr. Tillyard has kindly read over the completed paper and helped me by a full and careful criticism. To all of these gentlemen I desire to express my grateful thanks.

CHARACTERS OF THE GENUS.

BORKHAUSENIA Hubner, *Verz. bek. Schmett.*, p. 420, 1826.

I take the definition of the genus from Meyrick as given in the *Genera Insectorum*, fasc. 180, p. 37, inserting (in square brackets) the notation of the venation according to the Comstock-Needham system.

Head smooth, side-tufts loosely appressed; ocelli posterior: tongue developed. Antennae $\frac{3}{4}$, in male moderately or rather strongly ciliated (1–3), basal joint moderate, with pecten. Labial palpi moderate or long, curved, ascending, second joint usually nearly reaching base of antennae, with appressed scales, somewhat loose beneath, terminal joint shorter than second, moderate, acute. Maxillary palpi very short, filiform, appressed to tongue. Posterior tibiae clothed with long fine hairs. Forewings with 1*b* furcate [1A and 2A coalescing near base], 2 [Cu_{1b}] from or near angle, 7 and 8 [R_5 and R_4] stalked, 7 [R_5] to costa, 11 from middle [*rf* at $\frac{1}{2}$]. Hindwings under 1, elongate-ovate, cilia $\frac{2}{3}$–1; 3 and 4 [Cu_{1a} and M_3] connate, 5–7 [M_2, M_1, and Rs] nearly parallel.

Table of the Species.*

1. *B. honorata* Philp., *Trans. N.Z. Inst.*, vol. 50, p. 128, 1918.
2. *B. chrysogramma* (Meyr.), *ibid.*, vol. 16, p. 44, 1884.
3. *B. compsogramma* Meyr., *ibid.*, vol. 52, p. 31, 1920.
4. *B. xanthodesma* Philp., *ibid.*, vol. 54, p. 151, 1924.
5. *B. hoplodesma* (Meyr.), *ibid.*, vol. 16, p. 44, 1884.
6. *B. loxotis* Meyr., *Trans. Ent. Soc. Lond.*, p. 241, 1905.
7. *B. xanthomicta* Meyr., *Trans. N.Z. Inst.*, vol. 48, p. 415, 1916.
8. *B. siderodeta* (Meyr.), *ibid.*, vol 16, p. 43, 1884.
9. *B. melanamma* Meyr., *Trans. Ent. Soc. Lond.*, p. 240, 1905.
10. *B. sabulosa* Philp., *Trans. N.Z. Inst.*, vol. 50, p. 128, 1918.
11. *B. paratrimma* Meyr., *ibid.*, vol. 42, p. 65, 1910.
12. *B. siderota* (Meyr.), *ibid.*, vol. 20, p. 82, 1888.
13. *B. robiginosa* (Philp.), *ibid.*, vol. 47, p. 200, 1915.
14. *B. monodonta* (Meyr.), *ibid.*, vol. 43, p. 75, 1911.
15. *B. afflicta* n. sp. (described below).
16. *B. oxyina* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 45, 1884.
17. *B. amiculata* n. sp. (described below).
18. *B. aphrontis* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 46, 1884.
19. *B. epichalca* (Meyr.), *Proc. Linn. Soc. N.S.W.*, vol. 10, p. 793, 1886.
20. *B. maranta* (Meyr.), *ibid.*, vol. 10, p. 791, 1886.
21. *B. nycteris* (Meyr.), *Trans. N.Z. Inst.*, vol. 22, p. 219, 1890.
22. *B. thalerodes* Meyr., *ibid.*, vol. 48, p. 416, 1916.
23. *B. homodoxa* (Meyr.), *ibid.*, vol. 16, p. 43, 1884.
24. *B. macarella* (Meyr.), *ibid.*, vol. 16, p. 43, 1884.
25. *B. freta* n. sp. (described below).
26. *B. anaema* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 42, 1884.
27. *B. serena* n. sp. (described below).
28. *B. apanthes* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 41, 1884.
29. *B. armigerella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 29, p. 698, 1864.
30. *B. pharmactis* Meyr., *Trans. Ent. Soc. Lond.*, p. 241, 1905.
31. *B. horaea* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 40, 1884.
32. *B. hastata* Philp., *ibid.*, vol. 48, p. 422, 1916.
33. *B. apertella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 29, p. 698, 1864.
34. *B. eriphaea* Meyr., *Trans. N.Z. Inst.*, vol. 46, p. 107, 1914.
35. *B. phegophylla* (Meyr.), *ibid.*, vol. 16, p. 39, 1884.
36. *B. perichlora* Meyr., *ibid.*, vol. 39, p. 118, 1907.
37. *B. basella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 28, p. 492, 1863.
38. *B. politis* (Meyr.), *Trans. N.Z. Inst.*, vol. 20, p. 81, 1888.
39. *B. pronephela* Meyr., *ibid.*, vol. 39, p. 119, 1907.
40. *B. griseata* (Butl.), *Proc. Zool. Soc. Lond.*, p. 405, 1877.
41. *B. innotella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 29, p. 652, 1864.
42. *B. brachyacma* Meyr., *Trans. N.Z. Inst.*, vol. 41, p. 13, 1909.
43. *B. chloradelpha* Meyr., *Trans. Ent. Soc. Lond.*, p. 239, 1905.
44. *B. penthalea* Meyr., *ibid.*, p. 239, 1905.
45. *B. amnopis* Meyr., *Trans. N.Z. Inst.*, vol. 42, p. 65, 1910.
46. *B. ancogramma* Meyr., *ibid.*, vol. 51, p. 352, 1919.
47. *B. opaca* n. sp. (described below).
48. *B. hemimochla* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 38, 1884.

* Since the completion of this paper Mr. Meyrick has described another species, *B idiogama* (*Trans. N.Z. Inst.*, vol. 55, p. 661, 1924). It appears to belong to the *plagiatella* group.

49. *B. crotala* Meyr., *ibid.*, vol. 47, p. 213, 1915.
50. *B. plagiatella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 28, p. 485, 1863.
51. *B. morosa* n. sp. (described below).
52. *B. epimylia* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 36, 1884.
53. *B. pallidula* Philp., *ibid.*, vol. 55, p. 210, 1924.
54. *B. seclusa* Philp., *ibid.*, vol. 53, p. 340, 1921.
55. *B. collitella* (Walk.), *List Lep. Het. Brit. Mus.*, vol. 29, p. 655, 1864.
56. *B. chloritis* (Meyr.), *Trans. N.Z. Inst.*, vol. 16, p. 36, 1884.
57. *B. letharga* (Meyr.), *ibid.*, vol. 16, p. 35, 1884.
58. *B. scholaea* (Meyr.), *ibid.*, vol. 16, p. 35, 1884.
59. *B. fenestrata* n. sp. (described below).
60. *B. pseudospretella* (Stt.), *Cat. Brit. Tin.*, p. 14, 1849.

NOTES ON THE ABOVE LIST.

Borkhausenia cenchrias Meyr. (*Trans. N.Z. Inst.*, vol. 41, p. 13, 1909).—This species has been removed to *Gymnobathra*.

B. asphaltis Meyr. (*Trans. N.Z. Inst.*, vol. 43, p. 65, 1911).—On closer examination this proves to be a *Guestia*.

B. thranias Meyr. (*Trans. Ent. Soc. Lond.*, p. 240, 1905).—Sunk as a synonym of *B. hoplodesma* Meyr.

B. siderodeta Meyr.—This is a widely-varying species as regards size, ranging from the very small race (10–11 mm. in wing-expanse), found in Nelson, to the large Stewart Island form, which expands 14–16 mm.

B. chloradelpha Meyr.—I cannot detect any differences between the male genitalia of this and *B. perichlora* Meyr. The species can be separated only on colour characters, and it seems probable that the two forms represent only the northern and southern varieties of the one species.

B. crotala Meyr.—The genital differences between this and *B. plagiatella* Walk. are very slight. The prong on the upper angle of the valva in *plagiatella* is a little more curved round than in *crotala*, and the uncus differs a little in shape. Series of the two species show constant difference in appearance, though not perhaps more than is observable between series of other species from different localities. On the whole, it seems desirable to separate the two forms, though eventually the distinction may prove to be of no more than varietal value.

DESCRIPTION OF NEW SPECIES.

Borkhausenia afflicta n. sp.

♂. 13½–14½ mm. Head, antennae, and thorax shining dark purplish-fuscous, antennal ciliations in male 3, whorled. Palpi shining dark purplish-fuscous, second segment ochreous within. Abdomen dark fuscous. Legs whitish ochreous, strongly infuscated, tarsi obscurely annulated with ochreous. Forewings moderate, hardly dilated, costa moderately arched, apex rounded, termen hardly rounded, oblique; dark fuscous, slightly purplish; a patch of yellow scales round base of dorsum, sometimes mixed with orange but frequently absent altogether; sometimes a few similar scales on base of costa; from middle of dorsum a band of white to orange scales rises and curves down again to dorsum; frequently there are no markings or only a few coloured scales: fringes dark fuscous. Hindwings dark bronzy-fuscous: fringes dark greyish-fuscous with darker basal line.

♀. 13–15½ mm. Head and antennae fuscous mixed with ochreous. Palpi whitish-ochreous, outwardly more or less infuscated. Thorax and abdomen bronzy-fuscous. Legs ochreous, anterior pair infuscated. Forewings, contour as in male; greyish-fuscous, densely irrorated with yellow, ochreous, and orange, the colour being brightest on and below fold near base; fringes grey-fuscous mixed with ochreous. Hindwings as in male but rather paler.

Differs from *B. monodonta* (Meyr.) in the less dilated forewings and the shorter antennal ciliations in the male. The markings are usually of much less extent, though both species vary considerably in this regard. The genitalia of the males are very similar, but the lower lobe of the valva is distinctly longer and narrower in *B. afflicta*.

Abundant in forest during November on the Dun Mountain track, at elevations of from 2,000 ft. to 2,500 ft. Holotype (♂), allotype (♀), and a long series of paratypes in coll. Cawthron Institute.

Borkhausenia amiculata n. sp.

♂. 16½–17½ mm. Head dark brown. Palpi dark brown mixed with yellow. Antennae dark brown annulated with yellow, ciliations in male 1. Thorax dark brown, tegulae and posterior margin tipped with yellow. Abdomen dark coppery-brown. Legs ochreous mixed with brown, tarsi annulated with ochreous. Forewings moderate, costa moderately arched, apex rather pointed, termen slightly rounded, oblique; dull greyish-ochreous tinged with ferruginous; costal edge at base brown for a short distance, thence yellowish to near apex; a stripe of pale yellow from base of dorsum to tornus, apically attenuated; a small ferruginous spot on upper margin of dorsal stripe at ½; a ferruginous discal spot; an indistinct deeply-excurved ferruginous subterminal line, sometimes obsolete: fringes ochreous mixed with yellow points. Hindwings coppery-fuscous: fringes fuscous with darker basal line.

Much smaller than *B. basella* (Walk.), to which it bears considerable resemblance.

Cobb Valley, in December, and Mount Arthur Tableland (4,500 ft.), in the same month. Found among *Veronica* and other small shrubs. Holotype (♂) and one male paratype in coll. Cawthron Institute.

Borkhausenia freta n. sp.

♂ ♀. 14–15 mm. Head dark greyish-fuscous. Palpi yellow, second segment without and terminal segment strongly infuscated. Antennae greyish-fuscous annulated with yellow. Thorax dark greyish-fuscous, tips of tegulae yellow and a small yellow patch on posterior margin. Abdomen fuscous-grey, brassy-yellow dorsally. Legs pale-yellowish, anterior pair strongly infuscated. Forewing moderate, costa well arched, apex obtuse, termen rounded, oblique; clear yellow, thickly irrorated with dark ochreous on apical half and with a few ochreous scales on basal half; a small area of dark greyish-fuscous on upper half at base, extending for a short distance along costa: fringes concolorous with wing. Hindwings fuscous-grey: fringes grey with an obscure darker basal line.

Near *B. macarella* (Meyr.), but the dark head and thorax at once distinguish it.

Nelson; common in plantations and about cultivated land from November to January. Holotype (♀), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

Borkhausenia serena n. sp.

♂ ♀. 13–15 mm. Head and palpi whitish-ochreous mixed with brown. Antennae brown annulated with ochreous, ciliations in male $\frac{1}{2}$. Thorax brown, apices of tegulae pale ochreous. Abdomen grey annulated with brown. Legs ochreous, more or less infuscated. Forewings moderate, costa moderately arched, apex rounded, termen very oblique, whitish-ochreous; costa rather broadly brown on basal $\frac{1}{3}$; an irregular brown irroration all over wing, usually obsolete on dorsal region at base and beneath and following brown costal basal area; this brown irroration tends to form a spot above dorsum at before $\frac{1}{2}$ and an inwardly-oblique striga from tornus; an angled subterminal brown line faintly indicated: fringes pale ochreous with several rows of dark points. Hindwings greyish-fuscous: fringes grey with an obscure darker basal line.

An obscure species, not closely resembling any other, but nearest to the much larger *B. innotella* (Walk.).

"Sunnyside" (Waiau); a male and two females taken in bush on a hillside in January. Holotype (♀) and one paratype in coll. A. Philpott.

Borkhausenia opaca n. sp.

♂ ♀. 15–16 mm. Head dark ochreous. Palpi ochreous mixed with fuscous. Antennae dark brown, ciliations in male $2\frac{1}{2}$, whorled. Thorax ochreous mixed with dark brown, tips of tegulae whitish. Abdomen dark shining metallic brown on basal segments, median and posterior segments with yellow band followed by whitish margin, anal tuft ochreous mixed with brown. Legs ochreous, more or less infuscated, tarsi annulated with whitish-ochreous. Forewings, costa hardly arched, apex round-pointed, termen almost straight, oblique; ochreous mixed with ferruginous and whitish; a stripe along dorsum more clearly yellow; a suffused ferruginous fascia from costa beyond middle towards dorsum at $\frac{1}{2}$, ending in a blackish spot below fold; a whitish area posterior to this black spot; a dark ferruginous fascia from tornus, coalescing with median fascia below costa: fringes ochreous, mixed with ferruginous basally. Hindwings greyish-fuscous: fringes fuscous-grey with obscure dark basal line.

A pale member of the *monodonta* group, but the antennal ciliations in the male are much shorter than those of its allies.

Bluff; five specimens, in November and December. Holotype (♂), allotype (♀), and three paratypes in coll. A. Philpott.

Borkhausenia morosa n. sp.

♂ ♀. 13–15 mm. Head and thorax grey. Palpi ochreous, second segment outwardly dark fuscous and terminal segment with fuscous supra-basal ring and irregular markings. Antennae grey. Abdomen fuscous-grey. Legs whitish-ochreous, anterior pairs infuscated. Forewings elongate, costa slightly arched, apex obtuse, termen slightly rounded, oblique; markings very obscure and irregular, frequently absent; a suffused blackish-fuscous fascia from costa at base to above dorsum at $\frac{1}{3}$, enclosing the ochreous or yellow plical stigma and usually anteriorly margined with yellowish; an interrupted black or dark-fuscous straight fascia from costa at $\frac{1}{3}$, coalescing with first fascia above dorsum, posteriorly margined with white and including the first discal stigma; an undefined blackish fascia from beyond middle to tornus, usually enclosing some ochreous scales in disc; a white subterminal line interruptedly margined

on both sides with blackish; frequently a considerable irroration of yellowish on apical area: fringes fuscous-grey mixed with blackish. Hindwings and fringes pale fuscous-grey.

Close to *B. crotala* Meyr. and *B. plagiatella* (Walk.), but smaller and darker than either.

Nelson; common in forest from November to February, and taken as high as 3,000 ft. on the Dun Mountain. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

Borkhausenia fenestrata n. sp.

♂ ♀. 10½–12 mm. Head dull brown, mixed with ochreous posteriorly. Palpi bright ochreous mixed with brown. Antennae brown annulated with ochreous, ciliations in male 2½. Thorax bronzy-brown. Abdomen pale bronzy-brown. Legs pale ochreous mixed with brown, tarsi obscurely annulated with paler. Forewings moderate, costa moderately arched, apex obtuse, termen rounded, oblique; pale dull-brown; first discal indicated by a few scattered brownish-black scales; plical obliquely beyond first discal, very small, sometimes consisting of one scale only; second discal larger, lower half white; a very obscure irregular dark-brown subterminal line: fringes dull-brownish mixed with pale ochreous and darker brown. Hindwings bronzy-fuscous: fringes fuscous-grey with darker basal line.

A very obscure but isolated and distinct form; the rather conspicuous parti-coloured second discal is a good specific character.

Dun Mountain, Nelson; fairly common in forest from 2,000 ft. to 3,000 ft. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

Key to the Species.*

Owing to the fact that many of the species are very obscurely marked and offer little of a definite nature for characterization, the preparation of a key has been a matter of considerable difficulty. That offered is admittedly imperfect, but may be of use when supported by the study of the full descriptions. The antennal ciliations of the male often offer good distinguishing characters, but I have not thought it advisable to use such as a primary indication of species, as the antennae of the female usually afford no specific distinctions. In the case of several forms, as no specimens exist in New Zealand collections, I have had to rely on descriptions only, and in one instance (*B. collitella* Walk.), as neither specimen nor description was available to me, I have perforce omitted the species from the table.

1.	Forewings more or less yellow or ochreous	2
	Forewings not yellow or ochreous	18
2.	Forewings lanceolate	3
	Forewings not lanceolate	4
3.	Wings of normal breadth; forewings with terminal series of blackish dots	*hastata.*
	Wings narrow; forewings without terminal series of blackish dots	*maranta.*
4.	Costa of forewings margined with fuscous basally	5
	Costa of forewings not so margined	16
5.	Basal half of forewings suffused with fuscous	*amnopis.*
	Basal half of forewings not so suffused	6
6.	Head yellow or whitish-ochreous	7
	Head greyish-fuscous; wing-expanse 14–15 mm.	*freta.*

* *B. siderota* has inadvertently been left out of the key. The species can, however, easily be recognized by its brilliant colour and the leaden-metallic fasciae.

7. Forewings clear yellow	8
Forewings not clear yellow	11
8. Forewings with transverse fasciae, sometimes obsolete; wing-expanse 12–13 mm.	*hoplodesma.*
Forewings without transverse fasciae	9
9. Fuscous basal margining of costa confined to extreme edge; forewings deep ochreous-yellow	*pharmactis.*
Fuscous basal margining of costa not so confined	10
10. Antennae dark fuscous; forewings deep yellow	*armigerella.*
Antennae ochreous-whitish; forewings pale yellow	*macarella.*
11. Fuscous basal margining of costa confined to extreme edge; forewings whitish-ochreous ..	*chlorodelpha.*
Fuscous basal margining of costa suffused	12
12. Head whitish-ochreous mixed with brownish	13
Head not mixed with brown	14
13.*	*serena.*
.. ..	*anaema.*
14. Thorax mostly dark fuscous; forewings pale dull whitish-yellow	*chloritis.*
Forewings mostly light fuscous	15
15. Forewings ochreous tinged	*horaea.*
Forewings not ochreous tinged	*apanthes.*
16. Hindwings dark fuscous; forewings yellow, sprinkled with leaden grey	*aphrontis.*
Hindwings not dark fuscous	17
17. Forewings deep yellow	*apertella.*
Forewings bronzy-ochreous	*epichalca.*
18. Forewings with more or less ferruginous	19
Forewings without ferruginous	28
19. Forewings deep ferruginous	20
Forewings light ferruginous	23
20. Forewings with paler dorsal stripe or markings	21
Forewings without such markings; wing-expanse 13–15 mm. ..	*oxyina.*
21. Forewings mixed with grey; wing-expanse 17 mm.	*thalerodes.*
Forewings not mixed with grey	22
22. Forewings with dorsal stripe entire; antennal ciliations in male short, 1	*basella.*
Forewings with dorsal stripe interrupted; antennal ciliations in male long, 3	*robiginosa.*
23. Forewings with paler dorsal stripe..	24
Forewings without dorsal stripe	27
24. Head dark-brownish	*amiculata.*
Head ochreous or whitish-ochreous	25
25. Hindwings grey-whitish; wing-expanse 20–22 mm.	*perichlora.*
Hindwings fuscous-grey	26
26. Forewings with oblique dark fascia from dorsum; antennal ciliations in male long, nearly 3	*opaca.*
Forewings without such fascia; antennal ciliations in male short, 1½	*politis.*
27. Costa of forewings strongly arched	*scholaea.*
Costa of forewings gently arched	*eriphaea.*
28. Forewings dark fuscous	29
Forewings not dark fuscous	36
29. Dorsum of forewings with complete or interrupted paler stripe	30
Dorsum of forewings without such stripe	31
30. Forewings with broad yellow subterminal fascia; antennal ciliations in male short, less than 1	*honorata.*
Forewings without such fascia; antennal ciliations in male long, 4½	*monodonta.*
31. Forewings with yellow or orange transverse fasciae	32
Forewings without such fasciae	35
32. Forewings with only one transverse fascia	*loxotis.*
Forewings with more than one transverse fascia	33

* There being no verified example of *B. anaema* in New Zealand collections, and it being found that no satisfactory character could be selected from the description to separate the species from *B. serena*, the matter is here left in doubt. Possibly *serena* is a synonym of *anaema*.

33.	Forewings with dull-yellow fasciae; number of fasciae 5 ..	*xanthodesma.*
	Forewings with bright-yellow or orange fasciae	34
34.	Forewings with clear golden-yellow fasciae; number of fasciae 4	*chrysogramma.*
	Forewings with clear orange-tinted fasciae; number of fasciae 5, third and fourth forming a loop	*compsogramma.*
35.	Forewings with oblique whitish fascia from tornus; antennal ciliations in male short, 1	*nycteris.*
	Forewings without oblique fascia from tornus; antennal ciliations in male long, 3	*afflicta.*
36.	Forewings brownish	37
	Forewings whitish or grey	49
37.	Forewings with pale dorsal area	38
	Forewings without pale dorsal area	40
38.	Head ochreous-grey; stigmata dark fuscous	*ancogramma.*
	Head ochreous-yellow	39
39.	Wing-expanse 16–17 mm.	*pronephela.*
	Wing-expanse 21–22 mm.	*phegophylla.*
40.	Forewings narrow, hardly posteriorly dilated	41
	Forewings broad, posteriorly dilated	46
41.	Second discal spot conspicuous, partly white; antennal ciliations in male 3	*fenestrata.*
	Second discal spot not conspicuous	42
42.	Forewings with costa bent at $\frac{1}{3}$, four obscure oblique fasciae ..	*melanamma.*
	Costa not bent	43
43.	Head dark fuscous; forewings sprinkled with grey	*xanthomicta.*
	Head more or less ochreous	44
44.	Wings long, 18–25 mm.; stigmata prominent	*pseudospretella.*
	Wings short, less than 16 mm.; stigmata obscure or absent ..	45
45.	Forewings ochreous-fulvous; hindwings grey	*paratrimma.*
	Forewings brownish-ochreous or fuscous; hindwings fuscous ..	*siderodeta.*
46.	Forewings with broad subterminal dark fascia	*penthalaea.*
	Forewings without such fascia	47
47.	Markings almost obsolete	*homodoxa.*
	Markings more definite	48
48.	Terminal segment of palpi short, about half second: forewings less dilated posteriorly	*brachyacma.*
	Terminal segment of palpi normal; forewings more dilated posteriorly	*innotella.*
49.	Forewings lanceolate, grey	*sabulosa.*
	Forewings not lanceolate	50
50.	Forewings with two widely separated brown fasciae	*griseata.*
	Forewings without such fasciae	51
51.	Head white	52
	Head not white	53
52.	Forewings with prominent oblique brownish fascia from base of costa; hindwings fuscous-grey	*plagiatella.*
	Forewings without such fascia; hindwings whitish-grey ..	*crotala.*
53.	Head ochreous-white	54
	Head not ochreous-white	56
54.	Costa of forewings without dark spots	*hemimochla.*
	Costa of forewings with dark spots or blotches	55
55.	Forewings with terminal series of fuscous dots	*pallidula.*
	Forewings without terminal series of dots	*letharga.*
56.	Head grey; forewings with ochreous markings	*morosa.*
	Head grey; forewings without ochreous markings	57
57.	Expanse of wing 16–17 mm.; forewings greyer	*seclusa.*
	Expanse of wing 11–13 mm.; forewings whiter	*epimylia.*

General Description of the Genitalia. (Figs. 7–10.)

The male genitalia in the New Zealand section of the genus are of comparatively simple form, though, for the most part, showing very distinct specific differences. The abdominal segments are rather weakly chitinized, and the inter-segmental membrane between the eighth and ninth is fairly extensive, allowing of the protrusion and withdrawal of the

genitalia. A short description of each structure is now given so as to facilitate the understanding of the figures.

The Ninth Sternite (Ventral Half of the Tegumen).—In many groups of Lepidoptera the ventral part of the sternite (known as the saccus) is produced basally, the plate so formed passing within the preceding segment

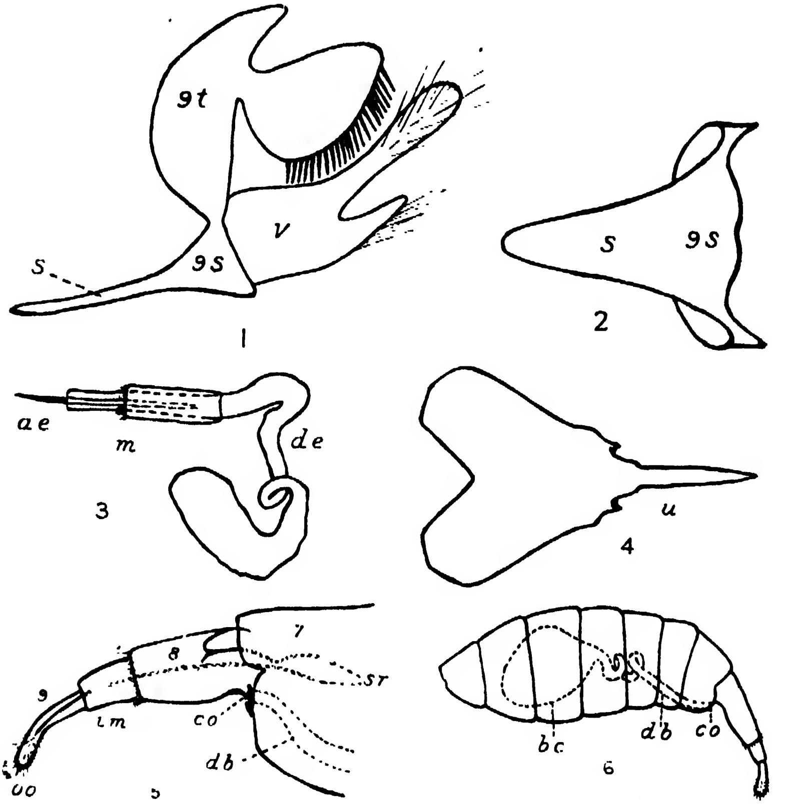


FIG. 1.—*Hieroxestis omoscopa* Meyr. Lateral view of male genitalia. *s*, saccus; *v*, valva; *9t*, ninth tergite; *9s*, ninth sternite.
FIG. 2.—*Hieroxestis omoscopa* Meyr. Ventral view of tegumen. *s*, saccus; *9s*, ninth sternite.
FIG. 3.—*Borkhausenia nycteris* (Meyr.). Penis. *ae*, aedeagus; *d.e*, ductus ejaculatorius; *m*, manica.
FIG. 4.—*Borkhausenia plagiatella* (Walk.). Dorsal view of ninth tergite. *u*, uncus.
FIG. 5.—*Borkhausenia basella* (Walk.). Female. Lateral view of apical abdominal segments. 7, 8, 9, seventh, eighth, and ninth segments; *c.o*, copulatory opening; *d.b*, ductus bursae; *i.m*, intersegmental membrane; *o.o*, opening of ovipositor; *s.r*, segmental rods.
FIG. 6.—*Borkhausenia basella* (Walk.). Female. Lateral view of abdomen. *b.c*, bursa copulatrix; *c.o*, copulatory opening; *d.b*, ductus bursa.

(see figs. 1 and 2). In *Borkhausenia* this plate is recurved, the part originally directed basally being so folded back as to project distally above the slight apical projection; this can be seen in any of the lateral views of the genitalia. This saccus is weakly chitinized, especially on the lateral portions. In a few species, such as *B. innotella* (Walk.), the stronger chitinization extends to the sides (see fig. of *B. innotella*).

The Valvae.—The valvae are well developed, broad, and more or less flat. The upper apical angle is generally produced into a downwards-curving process, and sometimes the lower angle bears a similar but smaller process tending to curve upwards. In the *siderodeta* group the lower process is absent, and the upper takes the form of a short and broad truncated projection. In a few species there is a median process, always small, and in some instances recurved inwardly. On the inner side the lower margin is seen to be folded in, and this folded portion always bears hairs of greater or lesser length and stoutness. The upper arm or process is also usually well armed with hair, but the stout stiff bristles forming the harpes in other groups of Lepidoptera are missing. About the middle of the basal part of the valva there is a longitudinal fold, from the apical portion of which a series of hairs rises. The base of this fold articulates with the juxta, a chitinous plate lying between the valva and supporting the penis.

The Penis.—The penis consists of a large chitinous tube, slightly curved downwards and usually a little swollen at its basal end, a short distance above which the ductus ejaculatorius enters. It is held in place by a membranous sleeve, the manica. Ventrally it is supported by the juxta, this latter structure varying in shape and frequently having some fine hairs on its apical portion. The intromittent organ (the aedeagus) is hard, slightly curved, thin, and pointed. (See fig. 3.)

The Ninth Tergite (Upper Half of Tegumen).—Basally the ninth tergite is deeply indented in the middle, thus forming two large lateral lobes (fig. 4). The gnathos is normally present, frequently showing greater development than the uncus. It is broad at the base, taking up the whole of the breadth of the tergite, but usually tapers to a point which lies between the valvae. In many species there is a projection on the outer surface of the gnathos, usually towards the base. In a few forms the organ is short and the apex outwardly recurved; in *B. hoplodesma* the gnathos is absent and the uncus is not defined. Between the bases of the gnathos and uncus the anal tube protrudes; this has been figured in only a few instances. The uncus is generally finger-like, occasionally straight, but usually curved or angled downwards; it does not bear an armature of backwardly-directed spines like that often present in other groups of the order. The outer surfaces of the valvae and tegumen are usually clothed more or less with weak hairs; these have been omitted in the figures.

It has not been considered necessary to give more than two drawings of the organs of each species; the first figure shows a lateral view of the structures *in situ*, and the second represents a valva viewed from within. In all cases the drawings have been made by camera lucida from material macerated in a 10-per-cent. solution of potash prior to mounting the preparation on a slide.

The Female Genitalia.—In the female the eighth and ninth segments are modified to perform the functions of an extensible ovipositor. Normally only a portion of the apices of these segments projects from the abdomen, but complete protrusion of both segments is possible (see figs. 5 and 6). The segmental rods are well developed, those of the ninth segment extending some distance into the seventh segment even when the organ is fully extended. The copulatory opening, which is situated between the seventh and eighth segments, has, in some species, a leaf-like chitinous piece on each side; in others this is absent and a portion of the ductus bursae is itself chitinized. The duct is a long thick tube which, after some convolutions, expands into the comparatively huge bursa copulatrix (fig. 6).

Of the sixty species listed herein I have been able to examine the male genitalia of forty-seven; nine species (*macarella, anaema, apanthes, horaea, phegophylla, griseata, collitella, chloritis,* and *letharga*) do not appear to be

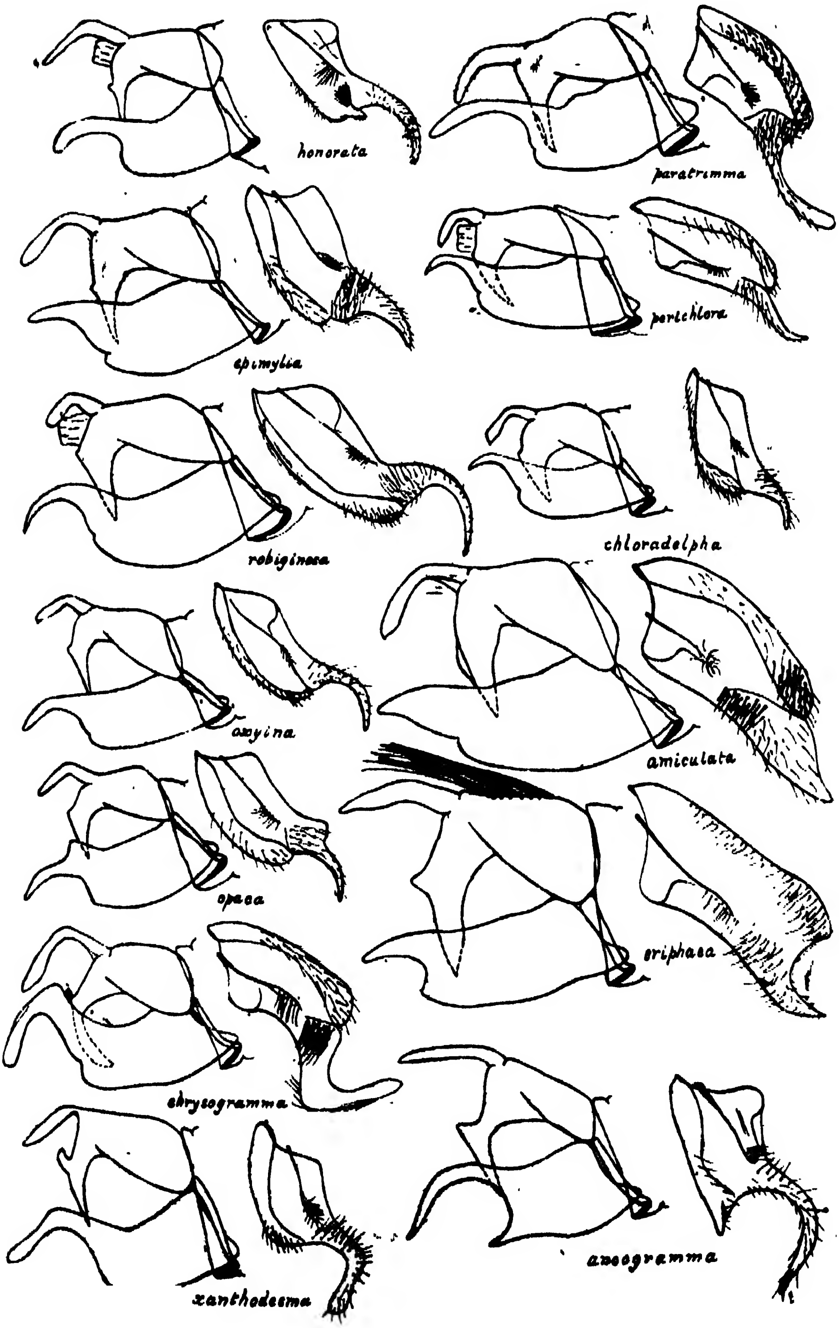


FIG. 7.—Two views each of genitalia of various species of *Borkhausenia.*

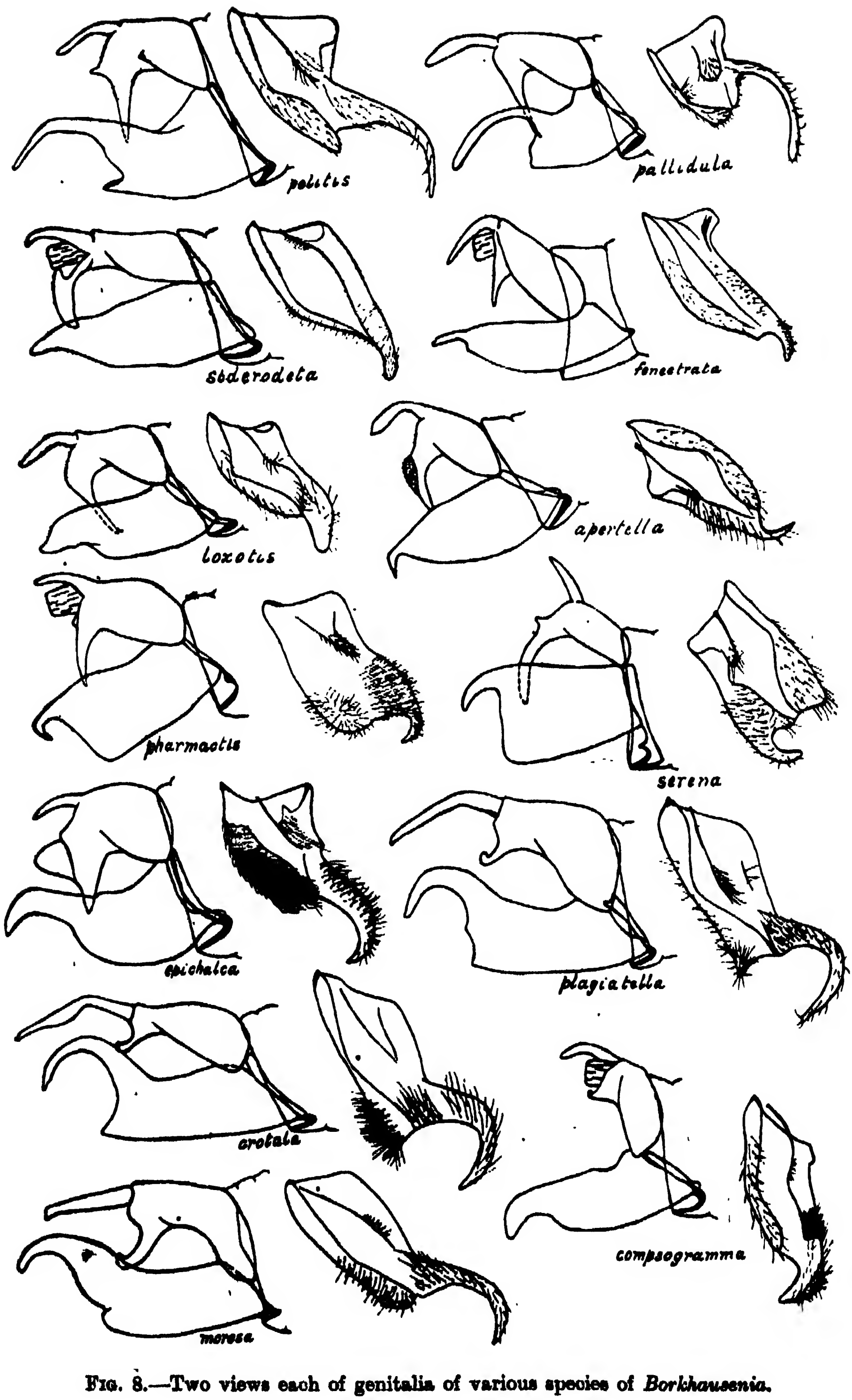


FIG. 8.—Two views each of genitalia of various species of *Borkhausenia*.

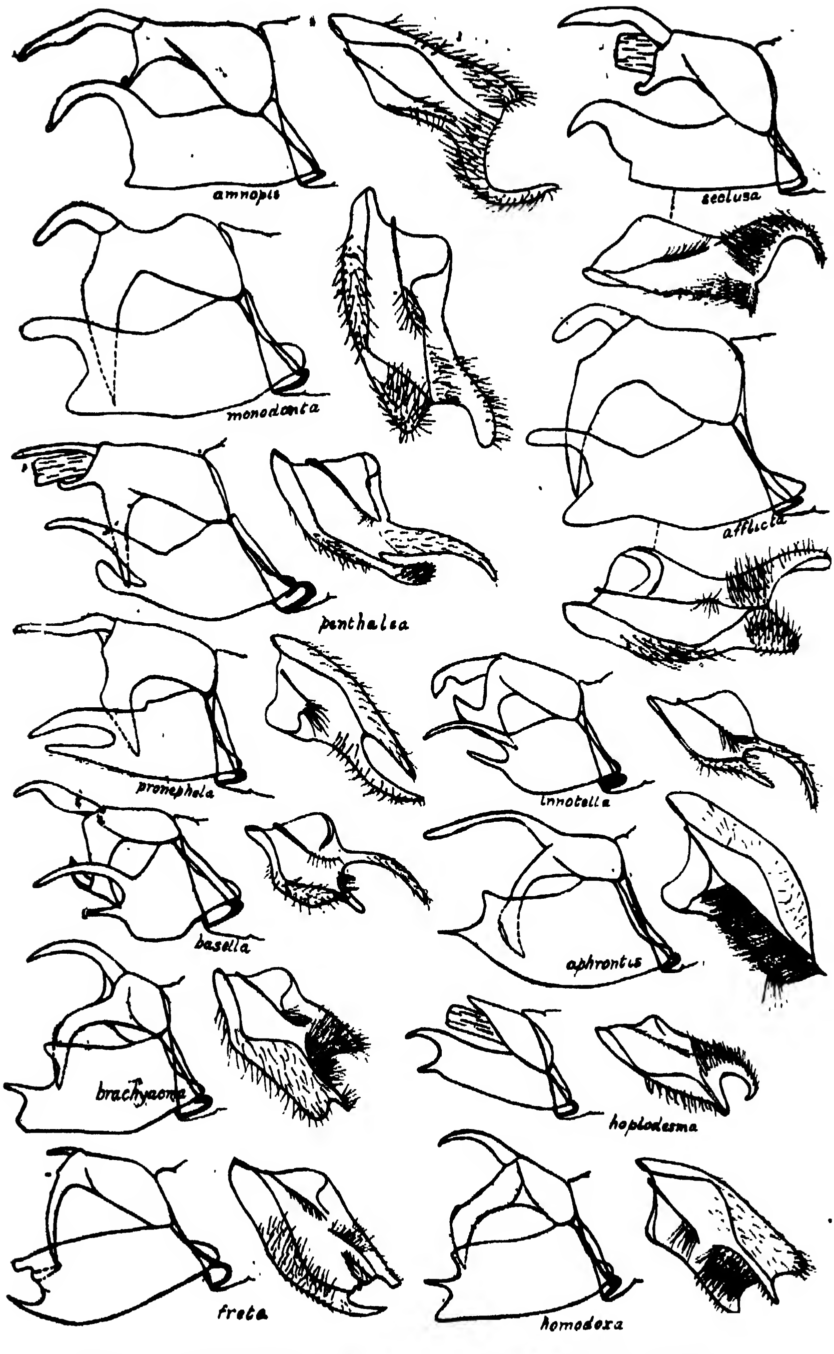


FIG. 9.—Two views each of genitalia of various species of *Borkhausenia.*

represented in New Zealand collections; of *sabulosa* and *hastata* only the types are known; of *hemimochla* I could obtain only the female; and of *thalerodes* I was not able to obtain a male for dissection, though, through the kindness of Mr. Hudson, I had the opportunity of examining the single male in his collection. As far as could be ascertained without dissection, the genitalia of this form appears to be of the *robiginosa* type.

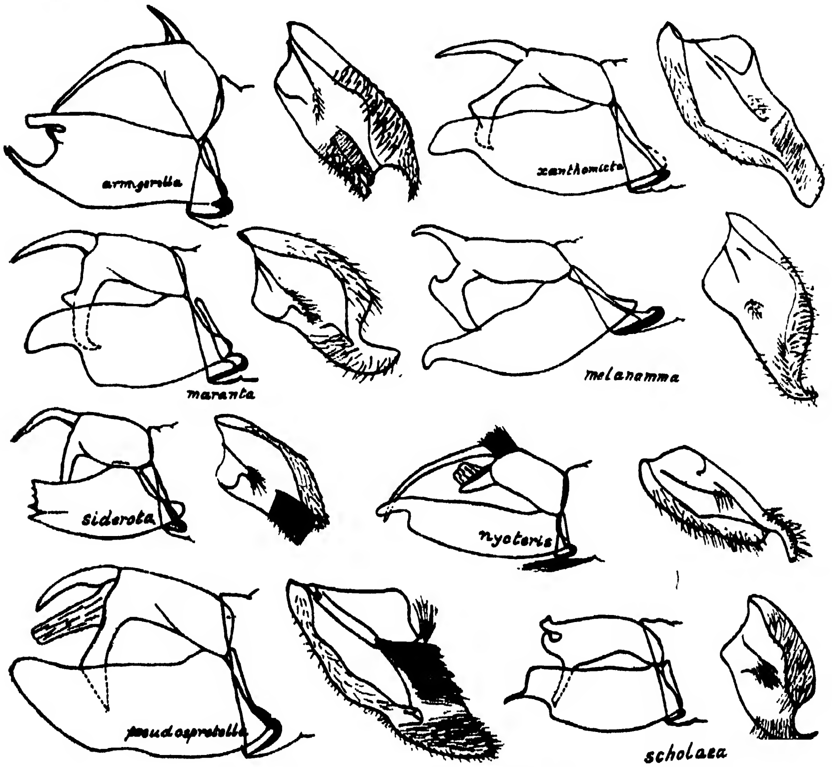


FIG. 10.—Two views each of genitalia of various species of *Borkhausenia.*

A study of the genitalia allows of the grouping of the species into several sections, and such sections agree fairly well with an arrangement founded on superficial resemblance. There are within the larger groups several subgroups; in the following table these have been indicated by the use of a semicolon :—

Group 1.—Upper angle of the valva produced in a curved process, or prong; the gnathos fairly straight and not recurved at the apex: *honorata, paratrimma, epimylia; perichlora, chloradelpha, robiginosa, oxyina, amiculata, opaca, eriphaea; chrysogramma, xanthodesma; ancogramma, politis; pallidula; siderodeta, loxotis; fenestrata; apertella, pharmactis, serena; epichalca.*

Group 2.—Valvae with upper prong only, but gnathos recurved at apex; the recurved portion usually bifid: *plagiatella, crotala, amnopis, seclusa, morosa; compsogramma.*

Group 3.—Valvae with both upper and lower prongs: *monodonta, afflicta; pronephela, penthalea; basella, innotella; aphrontis. Hoplodesma* is a member of the two-pronged group, but is unique in the absence of the gnathos.

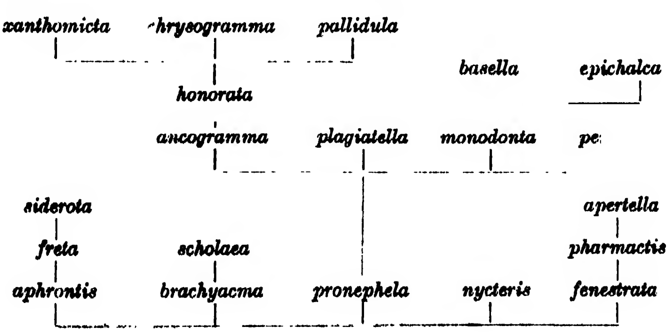
Group 4.—Valvae with a median prong, making three altogether; in such instances the prongs are all short, and may be only rounded prominences; the median one is sometimes recurved, and lies on the inner surface of the valva: *brachyacma, homodoxa: freta, armigerella.*

Group 5.—Valvae without prongs, but with the apical portion more or less narrowed; *xanthomicta, maranta: melanamma.*

Siderota has the apex of the valva armed with small pointed processes; it appears to come nearest to group 3. *Nycteris* is an isolated form coming under group 1 as to the valvae, but having the gnathos reduced to very small proportions, while the uncus is unusually long. *Scholaea* is also a form having no close relationship to other species; the short bifid uncus is quite unique. *Pseudospretella*, as might have been anticipated, shows considerable divergance from the endemic species. The uncus and gnathos are of the normal type of group 1, but the valvae have two internal processes not found in the other species; the dense patch of long fine hair rising from the inner median area is also a unique character.*

PHYLOGENY OF THE SPECIES.

In a recent letter to me Mr. Meyrick expresses the opinion that the whole of the New Zealand species of *Borkhausenia* are the descendants of one immigrant species. Working in accordance with that view, we may postulate a form like *hoplodesma* as this original immigrant. Here the genitalia are of sufficiently simple type; the valvae are of normal type, though possessing two small prongs; the ninth tergite can hardly be said to bear an uncus, and the gnathos is entirely absent. It is possible, of course, that this apparent simpleness may be the result of specialization, in which case our scheme of descent would be upset completely. Setting this possibility aside for the present, however, it may be useful to build up a tentative phylogenetic scheme, taking *hoplodesma* as the starting-point. In the following table one name in several instances does duty for a group of species, and it should be remembered that the conclusions reached are not all of the same value, some of them being much more probable than others. The development of the gnathos has been the main guide in the preparation of the tree, modified by the state of the apical portion of the valvae.



* It should be remembered that any reference to "uniqueness" applies to New Zealand species only, and of these only to such as have been available for examination.

A New Endemic Genus of Lepidoptera.

By Alfred Philpott, Assistant Entomologist, Cawthron Institute, Nelson.

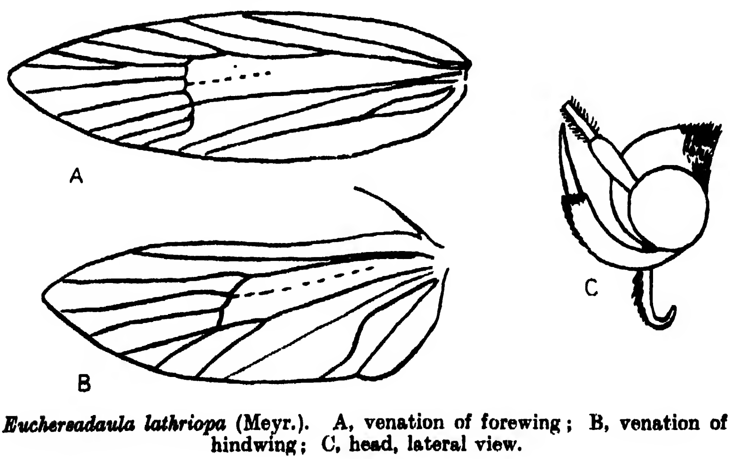
[*Read before the Nelson Philosophical Society, 11th June, 1924; received by Editor, 16th June, 1924; issued separately, 31st March, 1926.*]

It has become necessary to create a new genus for *Trachypepla lathriopa* Meyrick (*Trans. Ent. Soc. Lond.*, 1905, p. 237). While studying the genus *Borkhausenia* the writer had occasion to examine the species in question closely, and, without knowing its identity with *lathriopa*, discovered that it possessed characters which would not allow of its being placed in any known New Zealand genus. A specimen was submitted to Mr. Meyrick, who pronounced it to be his *lathriopa*, but agreed that it must be removed to a new genus, pointing out that its nearest affinities were with *Chersadaula* Meyr., from which it differed only in the presence of scale-tufts on the forewings, and the fully-winged female.

The writer proposes the name *Euchersadaula* for the genus, and gives below a synopsis of the characters, with some structural figures.

Euchersadaula n. g.

Head smooth, loosely haired behind; tongue developed. Antennae $\frac{3}{4}$, in male with short even ciliations, basal segment moderate, without pecten. Labial palpi rather long, recurved, second segment thickened, with appressed scales, terminal segment half as long as second, slender, acute.



Euchersadaula lathriopa **(Meyr.). A, venation of forewing; B, venation of hindwing; C, head, lateral view.**

Maxillary palpi minute, four-jointed. Thorax smooth. Posterior tibiae rather long-haired above. Forewings with slightly-raised tufts of scales, 1A and 2A coalescing at about $\frac{1}{3}$, Cu_{1a} and Cu_{1b} short-stalked, from angle, R_4 and R_5 stalked, R_5 to costa, *rf* at about $\frac{1}{4}$. Hindwings 1, fringes $\frac{3}{4}$, Cu_{1a} and M_3 connate, M_1 somewhat sinuate.

Genotype: *Trachypepla lathriopa* Meyr.

Descriptions of New Zealand Lepidoptera.

By EDWARD MEYRICK, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 27th August, 1924; received by Editor, 28th August, 1924; issued separately, 31st March, 1926.*]

THE following species have been communicated to me through the kindness of Mr. G. V. Hudson.

PYRAUSTIDAE.

Scoparia molifera n. sp.

♀. 20 mm. Head and thorax light-brownish, shoulders mixed dark fuscous. Palpi 3, brownish, base white. Forewings elongate rather dilated (rather narrower than *submarginalis*), termen nearly straight, somewhat oblique; brown, somewhat paler towards dorsum, costal third suffused dark fuscous, narrowed to apex; lines whitish, first at $\frac{1}{3}$, obtusely angulated below middle, second at $\frac{4}{5}$, indented towards costa and near dorsum, excurved between these, subterminal incurved on median third and confluent centrally with second; orbicular and discal spots confluent to form a broad dark-brown streak adjacent to dark-fuscous costal area, cut by first line and extending before it half-way to base, claviform elongate, dark brown, confluent with this on posterior edge of first line; dorsal third irrorated white between first and second lines; a slender dark-fuscous terminal shade including a waved white marginal line: cilia pale-greyish, an interrupted fuscous median line on upper part of termen. Hindwings $1\frac{1}{3}$, whitish-grey-ochreous; cilia ochreous-whitish.

Ashhurst, Manawatu River, in February; one specimen. A very distinct species, possibly allied (but not closely) to *submarginalis*.

TORTRICIDAE.

Catamacta calligypsa n. sp.

♀. 16 mm. Head and thorax white, slightly speckled grey. Palpi 2, whitish, sprinkled dark grey. Forewings suboblong, slightly dilated posteriorly, costa strongly arched towards base, then faintly sinuate, apex obtuse, termen slightly sinuate, somewhat oblique; white; basal patch grey with some strigulae of blackish irroration, suffused white towards costa, edge running from $\frac{1}{4}$ of costa to $\frac{2}{5}$ of dorsum, slightly irregular, central fascia represented by a faint greyish spot on costa at $\frac{2}{5}$, a grey spot on dorsum beyond middle, and a faint greyish cloud above this; on costa posteriorly an oblong blotch of grey suffusion with some dots of blackish irroration, enclosing a small white spot on costa; an irregular transverse blotch of grey suffusion extending from tornus before termen to above middle; two or three scattered blackish dots on costa; three blackish strigulae on apical part of termen: cilia white, extreme base grey, a strong rather dark grey median shade. Hindwings whitish, with small scattered light-grey spots or strigulae; cilia whitish.

Wellington, in February; one specimen.

Oecophoridae.

Trachypepla eumenopa n. sp.

♂♀. 12 mm. Head pale ochreous, more or less irrorated fuscous. Palpi pale ochreous sprinkled blackish. Antennal ciliations in male 2. Thorax ferruginous-ochreous irrorated dark fuscous. Abdomen dark grey. Forewings elongate, apex obtuse, termen obliquely rounded; violet-grey irrorated dark fuscous, disc more or less wholly suffused deep ferruginous-brown; some ochreous marking near base; stigmata forming raised tufts, plical beneath first discal, both these irrorated blackish, second discal forming an irregular white dot partially edged blackish irroration, some bright ochreous suffusion beneath this; two rather oblique irregular whitish striae crossing wing between discal stigmata, confluent and yellowish on costa, becoming obsolete towards dorsum; an indistinct yellowish spot on costa at ⅘; an irregular whitish spot just before apex, and series of scattered scales before termen: cilia yellow-whitish with two broad shades, first yellow-brownish, second purplish, purplish blotches at apex and on costa towards apex. Hindwings and cilia blackish-grey.

Wainuiomata, in December; two specimens.

Heliodinidae.

Stathmopoda trimolybdias n. sp.

♀. 14 mm. Head glossy whitish-violet-grey, back of crown orange. Palpi ochreous-whitish. Thorax glossy dark violet-grey, two indistinct narrow orange stripes. Forewings narrowed from near base, pointed; orange; costal edge dark grey from base to ⅔; three irregular dark leaden-metallic fasciae edged dark grey, first near base, prominent posteriorly near costa, second before middle, rather outwards-oblique from dorsum, not quite reaching costa, third from costa at ⅔, hardly reaching tornus; a faint narrow streak of greyish suffusion from middle of third fascia to apex: cilia grey, round apex light orange. Hindwings dark grey; cilia grey.

Ashhurst, Manawatu River, in February; one specimen.

Stathmopoda aristodoxa n. sp.

♂. 13 mm. Head silvery-white, crown grey. Palpi white. Thorax shining white, shoulders dark grey, edged posteriorly with some ferruginous scales. Forewings narrowed from near base, acute; pale ochreous; costal edge suffused dark grey from base to ⅓, thence undefined broader violet-grey costal suffusion to ⅔; an oblique blotch of dark violet-grey suffusion from base of costa, whence a slender ferruginous-brown partially grey-suffused supramedian streak runs to just below apex, its apex enlarged into a wedge-shaped spot; two shining snow-white dorsal blotches reaching supramedian streak, first semicircular, second suboval, inwards-oblique, these preceded, separated, and followed by spots of orange-ferruginous suffusion somewhat marked irregularly dark grey; some orange-ferruginous suffusion along termen except at apex: cilia grey, on costa mixed pale ochreous. Hindwings rather dark grey; cilia grey.

Wellington, in November; one specimen. Handsome and distinct; allied to *caminora*, which is certainly a variable species, but none of my series approach this insect, characterized by the shining snow-white thorax and dorsal blotches, of which the anterior is broad and semi-circular (in *caminora* outwards-oblique and pointed).

New Species of Lepidoptera.

By CHARLES E. CLARKE, F.E.S.

[*Read before the Otago Institute, 9th December, 1924; received by Editor, 31st December, 1924; issued separately, 10th April, 1926.*]

HYDRIOMENIDAE.

Xanthorhoe ida n. sp.

♂. 24 mm. Head, palpi, and thorax grey-fuscous. Antennae fuscous, pectinations 6. Abdomen grey-fuscous. Forewings elongate-triangular, costa outwardly rounded, apex bluntly pointed, termen slightly sinuate, oblique; brown-ocherous with admixture of reddish, lines white; an irregular wide transverse band at ¼, outwardly convex in middle, slightly reddish with narrow white edges on either side; at ⅔ a transverse dentate white line with largest dentations outwardly about middle; reddish beyond this and then darkening into brown-ochreous towards termen; a blackish discal dot; subterminal line dentate, white, inwardly edged with dark brown: cilia dark fuscous. Hindwings dark grey-ochreous on inner half, externally lighter ochreous, crenulate markings along termen: cilia dark fuscous.

Seven specimens, the first being taken by Mr. W. G. Howes, F.E.S., at the Eweburn Stream, near Mount Ida, Otago Central, in February, 1923.

Hydriomena callichlora harmonica n. subsp.

♂. 31 mm. Head, palpi, thorax, and abdomen orange mixed with grey. Forewings bright orange and pale cerulean blue in many wavy bands bordered in places with blackish; before middle a wide dentate orange band, centrally blue and with blackish edges; at ⅔ a blackish band with bidentate projection in middle; beyond this orange and blue crossed by wavy blackish lines; a bright-orange area posteriorly, crossed by another band of blue; and a row of small black dots along termen. Hindwings moderate, hind-margin rounded, crenate; grey-whitish with several indistinct grey lines across outer half.

Waitati Bush, near Dunedin, in November, 1917.

This beautiful and unique specimen is so different from my other examples, of which I have a good series from various localities, that it seems at first glance to be a new species. However, no structural difference has been noted in it from typical examples of *callichlora*.

CRAMBIDAE.

Crambus corylana n. sp.

♂. 36 mm. Head grey-white. Palpi white above and internally, ochreous externally. Antennae fuscous. Thorax white; patagia ochreous. Abdomen grey-whitish. Anterior legs light fuscous, posterior pair light ochreous. Forewings long, somewhat dilated posteriorly, costa slightly arched, apex bluntly pointed, termen slightly sinuate, oblique; grey-white, extreme costal edge fuscous widening at about ⅔ where it is ochreous; a broad ochreous stripe from base below middle to termen above tornus and extending across to dorsum from about ⅓ to tornus: cilia white, ochreous near dorsum. Hindwings pale ochreous-grey: cilia ochreous-grey.

Very close to *C. ephorus* but less bright. May be distinguished by the wide ochreous stripe extending transversely to dorsum along outer ⅔.

A good series in February, 1923, at the base of Mount Ida, Otago Central.

PYRAUSTIDAE.

Scoparia tuicana n. sp.

♂♀. 14 mm. Head and antennae ferruginous black; antennal ciliations $\frac{2}{3}$. Palpi and thorax black with sprinkling of grey-white scales. Abdomen ferruginous black dotted with grey scales. Fore legs black annulated with grey-white at joints, hind legs grey-whitish with blackish annulations on tarsi. Forewings moderate, triangular, costa posteriorly moderately arched, apex obtuse, termen slightly rounded, oblique; white and light ochreous vividly marked with black; a small whitish mark at base bordered by a black transverse band widening on inner margin, followed by a broader white transverse band indented at middle and dotted by some black scales which tend to form two obscure dots; a black transverse band from $\frac{1}{3}$ of costa, broken and rather diffused towards dorsum, often connected along costa at $\frac{2}{3}$ with a black transverse mark extending nearly half-way across wing, surrounded by a large area of whitish often slightly ochreous outwardly and towards dorsum; a black dot near costa at $\frac{3}{4}$, and a wide terminal band of black with an obscure whitish subterminal line: cilia blackish with narrow black subbasal line. Hindwings grey-ochreous merging into blackish outwardly; disc with a black dot sometimes comma-shaped: cilia blackish with black subbasal shade.

About twelve specimens taken during as many visits to the Waitati Hills and Mount Maungatua, 2,000 ft., in November, during three seasons.

Scoparia sylvestris n. sp.

♀. 18 mm. Head, palpi, and thorax dark green sprinkled with light fuscous. Antennae fuscous. Abdomen fuscous and grey. Legs fuscous with annulations of pale grey on tarsi. Forewings moderate, triangular, costa arched, apex obtuse, termen rounded; dark green obscurely irrorated with white; first line whitish, slightly convex outwardly with two or three irregular points, outwardly margined with darker and two orange spots; two whitish stigmata in disc slightly margined with orange; second line curved, deeply indented beneath costa, rather obscure; subterminal line wavy, diffused, and almost obsolete; a series of dots along termen: cilia dark green with two fuscous lines. Hindwings dark fuscous, more dark outwardly: cilia dark fuscous with two fuscous lines.

Two specimens taken and another seen near the Otira River, Westland, in January, 1923.

CARPOSINIDAE.

Carposina sanctimonea n. sp.

♂♀. 23 mm. Head whitish. Thorax grey-white. Palpi grey-white above with a few darker scales, fuscous below and near base. Antennae whitish, abdomen pale grey. Forewings elongate, posteriorly somewhat dilated, costa gently arched, apex bluntly acute, termen almost straight, oblique; pale grey-white with cloudy markings of dark fuscous; from base along costa a few scattered dark scales widening at about $\frac{3}{4}$ to a cloudy diffusion and tapering again to apex; from near base at middle a dark line, widest at about middle of disc where it ends but is almost connected with the dark diffusion from costa; a row of several black dots from near base on costal side of this, and another dot nearer to costa at about $\frac{1}{2}$; a black dot near anal angle; a blackish irroration with several dark spots subterminally and blackish along termen: cilia pale grey mixed with fuscous near apex. Hindwings pale grey-white: cilia grey-white.

Three specimens. Arthur's Pass, in January, 1923, at about 3,500 ft.

TORTRICIDAE.

Tortrix cuneata n. sp.

♂. 13 mm. Head and thorax light grey; palpi moderate. Antennae grey, antennal ciliations $\frac{1}{2}$. Abdomen pale ochreous-grey. Forewings elongate, costa moderately arched, apex bluntly pointed, termen slightly rounded, oblique; pale grey with a number of small obscure dots with tendency to form rows; a transverse blunt wedge-shaped red bar at $\frac{1}{2}$ of dorsum, reaching half-way across wing. Hindwings pale ochreous-grey: cilia pale grey.

Near *T. indigestana*, but smaller and differently marked.

One specimen, taken in a glade of the beech forest at Hope Arm, Lake Manapouri, in January, 1923.

Epichorista candida n. sp.

♀. 14 mm. Head, palpi, and thorax dark brown. Antennae brown annulated with whitish. Abdomen dark brown. Legs grey-brown. Forewings strongly arched near base, apex rectangular; termen rather sinuate; dark brown with a very wide irregular central band of pale and bright ochreous from about $\frac{1}{6}$ on costa to beyond $\frac{3}{5}$, its inner margin diagonally outward to fold, where it is longitudinally angulated and continues acutely diagonally outwards to almost reach dorsum at $\frac{1}{2}$; its outer margin from costa strongly indented to half-way across wing, where it extends outwardly a short distance and is angulated to proceed with a slight indentation to near dorsum at about $\frac{3}{4}$; pale ochreous excepting a bright ochreous transversely diagonal band from $\frac{1}{2}$ on costa, widening slightly where it almost reaches dorsum at $\frac{4}{5}$; a slightly curved grey subterminal line. Hindwings dark brown: all cilia brown mixed with ochreous on termen of forewing and near apex of hindwing.

One specimen, in January, 1923, taken at Hall's Arm, Lake Manapouri.

OECOPHORIDAE.

Gymnobathra zephyrana n. sp.

♂. 16 mm. Head and thorax brownish-fuscous. Palpi brownish-fuscous, second joint with several bristles externally. Antennae dark fuscous, basal joint brownish-ochreous. Abdomen and legs brown-fuscous, lighter at apex of tarsal joints and posterior tibiae. Forewings moderate, posteriorly dilated, costa moderately arched, apex acute, tornus rather produced, hind-margin sinuate, oblique; very dark fuscous; a longitudinal ochreous band along inner margin from base along dorsum about half width of wing gradually narrowing to an acute extremity close to tornus, broken by cloudy dark-fuscous scales from inner margin beyond base and narrowed anteriorly at nearly half length of wing by a slight projection of dark fuscous. Hindwings dark fuscous: all cilia dark fuscous.

A distinctive species belonging to the *hyetodes-philadelpha* group.

One specimen, taken in the forest near Whangarei on the 11th January, 1921.

Izatha toreuma n. sp.

♀. 23 mm. Head, thorax, and palpi greyish-white. Palpi black at base of second joint with some black scales round subapex, terminal joint with apex and a median band of black. Antennae dark fuscous, greyish-white at base. Thorax with a few darker scales each side of neck,

anteriorly at each side and posteriorly. Abdomen grey. Legs dark fuscous with lighter bands at joints; posterior tibiae light fuscous with some darker scales. Forewings moderate, costa gently arched, faintly sinuate in middle, apex obtuse, hind-margin oblique, nearly straight; greyish-white with narrowly defined black linear markings and dots: on base of costa a short narrow curved black line running into wing slightly at outward extremity, another very similar at about ¼, and an irregular trapezoidal spot on costa at nearly ⅗; on fold near base of wing a dot broken and then continued as a longitudinal line to rather less than ½, an anterior short transverse mark connecting with it at ⅕; two irregular spots slightly joined longitudinally along middle, and about midway from these to costa a dot at ⅓ and another at ½; a short longitudinal dot at about ¾ a short distance from costa, and another similarly distant from dorsum; a row of small spots along apical third of costa and termen: cilia grey-white. Hindwings grey, darker posteriorly with darker fuscous line along outer termen; an obscure dark-fuscous central spot: cilia grey.

One specimen. Arthur's Pass, 3,500 ft., in January.

Belongs to the *peroneonella-picarella-huttoni* group, but differentiated by the arrangement of the exceedingly narrow black lines on whitish-grey ground.

GLYPHIPTERYGIDAE.

Glyphipteryx scintilla n. sp.

♂♀. 9 mm. Head and thorax fuscous-bronze. Palpi loosely scaled, grey, with four black bands and black extremity. Antennae dark fuscous. Abdomen and legs dark fuscous, segmental margins greyish. Forewings elongate, costa gently arched, apex obtuse, oblique; dark fuscous-bronze; a strongly oblique whitish fascia from costa at ⅓ reaching about half-way across wing, five more silvery-white fascia from costa, the first two near middle rather oblique, the outer ones shorter and more transverse, reaching near to about six scattered dots and bars of metallic purple at outer disc and near termen; a black dot near apex, beneath which is a silvery-purple mark; a diagonal wedge-shaped white fascia from dorsum at about ⅓ reaching fold; a very small one at less than ¼, and another near tornus joining purple marks in outer disc: cilia whitish, basally bronzy-fuscous, indented subapically with white. Hindwings and cilia dark fuscous.

Rather close to *G. erastis*, but darker, less elongate, and the principal lines are differently and more diagonally placed.

A good series secured on Flat Mount, Hunter Mountains, near Lake Manapouri, at an elevation of 4,000 ft., in January, 1923.

Simaethis urbana n. sp

♂♀. 9¼ mm. Head fuscous with whitish scales. Palpi with whorls of white black-dotted scales with longer tuft beneath. Thorax bronzy-brown dotted with black and with longer scales. Legs dark fuscous irrorated with whitish. Antennae blackish annulated with grey. Abdomen dark fuscous, margins of segments grey. Forewings elongate, costa anteriorly arched, apex moderately obtuse, termen slightly rounded, oblique; dorsum gently oblique, rounded along inner half; bronzy-brown; a grey inwardly-oblique area at rather less than ⅓, distinct on dorsal side but obscurely reaching costa; a black transverse line at ⅓, convex outwardly with tendency to form about three dots across wing, outwardly bordered and dotted with metallic silvery markings; a bronzy-brown transverse area at

about $\frac{2}{3}$ crossed by grey, more definite towards dorsum; a row of metallic silvery dots at $\frac{5}{6}$ transversely to reach tornus; outwardly and at apex of wing blackish: cilia grey with black basal and median lines with suffusion of dark fuscous at apex and anal angle, tips whitish. Hindwings dark fuscous, lighter on basal half: cilia grey with dark-fuscous basal and fuscous median lines, tips whitish.

A distinct species, of which three specimens were taken together on the open mountain-side at Arthur's Pass, 4,000 ft., in January, 1923.

Simaethis chatuidea n. sp.

♂, 8 mm.; ♀, 9 mm. Head and thorax dark fuscous irrorated with violet-whitish scales. Palpi dark fuscous with whorls of blackish white-tipped scales. Antennae blackish annulated with white. Abdomen dark fuscous, segmental margins white; a few scattered white scales near extremity. Legs fuscous. Forewings suboblong, moderate, costa gently arched, apex obtuse, termen nearly straight, oblique; dark blue-violet; three distinct white spots on costa, central one at $\frac{1}{2}$, other two about equidistant with pale blue-violet transverse line proceeding from each; some violet-white irroration towards base; a transverse line from first white spot on costa, sometimes double, another from central costal spot, broken but often well angulated at middle; some violet-white irroration scattered across outer wing and a fine subterminal line: cilia dark ochreous with dark-fuscous basal and fuscous median lines, tips dark ochreous. Hindwings dark fuscous, darker outwardly, an incurved white streak, sometimes double, from $\frac{2}{3}$ of disc to tornus: cilia dark ochreous with fuscous lines, tips dark ochreous.

About twelve specimens of this species taken in November, 1923, at Vauxhall, Anderson's Bay, Dunedin.

TINEIDAE.

Tinea aetherea n. sp.

♂♀. 9–10 mm. Head grey-ochreous, lighter anteriorly. Palpi light grey-ochreous. Antennae grey-ochreous. Thorax fuscous sprinkled with grey-ochreous. Abdomen fuscous. Forewings elongate, rather narrow, costa gently arched, apex rather pointed, termen obliquely rounded; purplish-fuscous with grey-ochreous markings, of which there are three along costa with tendency to divide into double lines, oblique, central one from $\frac{1}{2}$ of costa, reaching about half-way across wing; three transverse marks from costa near apex, two outer ones again distinct on dorsum; near base and at $\frac{1}{3}$ and $\frac{2}{3}$ of dorsum are obscure wedge-shaped markings: cilia fuscous with blackish subbasal line and dark-fuscous subapical shade, grey-ochreous apically and subapically. Hindwings purplish-grey with dark-fuscous subbasal shade.

Three specimens. Arthur's Pass, at 3,500 ft., in January, 1923.

Mallobathra nocturna n. sp.

♂. 8 mm. Head, palpi, and antennae fuscous. Antennal ciliations 2. Thorax and legs fuscous. Abdomen light fuscous. Forewings elongate-oval, costa arched, apex rounded, hind-margin rather rounded; dark fuscous: cilia dark fuscous. Hindwings fuscous: cilia fuscous.

Two specimens taken and another seen at Kauri Gully, Northcote, Auckland, in January, 1921.

The Genus *Pachyrhamma* (Rhaphidophorinae: Orthoptera).

A New Species from New Zealand.

By D. D. Milligan, Research Student in Orthoptera, Cawthron Institute, Nelson, N.Z.

[*Read before the Nelson Institute, 1st October, 1924; received by Editor, 5th November, 1924; issued separately, 10th April, 1926.*]

Plates 79, 80.

Pachyrhamma acanthocera n. sp.

♂. General build and colouring as in *P. fascifer* Walk., but much larger, and having the colour-pattern much less strongly marked both on body and legs. The peculiarity which distinguishes this species from all the others so far known is that several of the antennal segments carry distinct spines. This peculiarity is emphasized by the specific name, suggested by Dr. R. J. Tillyard. The antennal segments number about 550, the basal one being stout, 3 mm. long, the second short and much narrower but noticeably broader than the rest, which form a long, slender, flexible flagellum; the segments following the second are irregular in length, often only partially divided into two, but, on the whole, steadily decreasing in individual length from the basal ones outwards. Segments 36 and 48 of right antenna, and segments 39 and 48 of left, have a sharp dorsal spine; segments 68, 70, 72 of right antenna, and 67, 69, 71, 73 of left, are distinctly knobbed distally on the outer side; segments 74 and 77 of right antenna, and segments 75 and 77 of left, carry sharp spines placed latero-ventrally on the outer distal margin. Total length of antenna, 183 mm.

Length of body, excluding antennae and cerci, 23 mm.

Breadth of head, 5·5 mm.; length of maxillary palpi, 20 mm.

Thorax: Pronotum 8 mm. long, 7 mm. wide; mesonotum 4 mm. long, 7·5 mm. wide; metanotum 4 mm. long, 7 mm. wide.

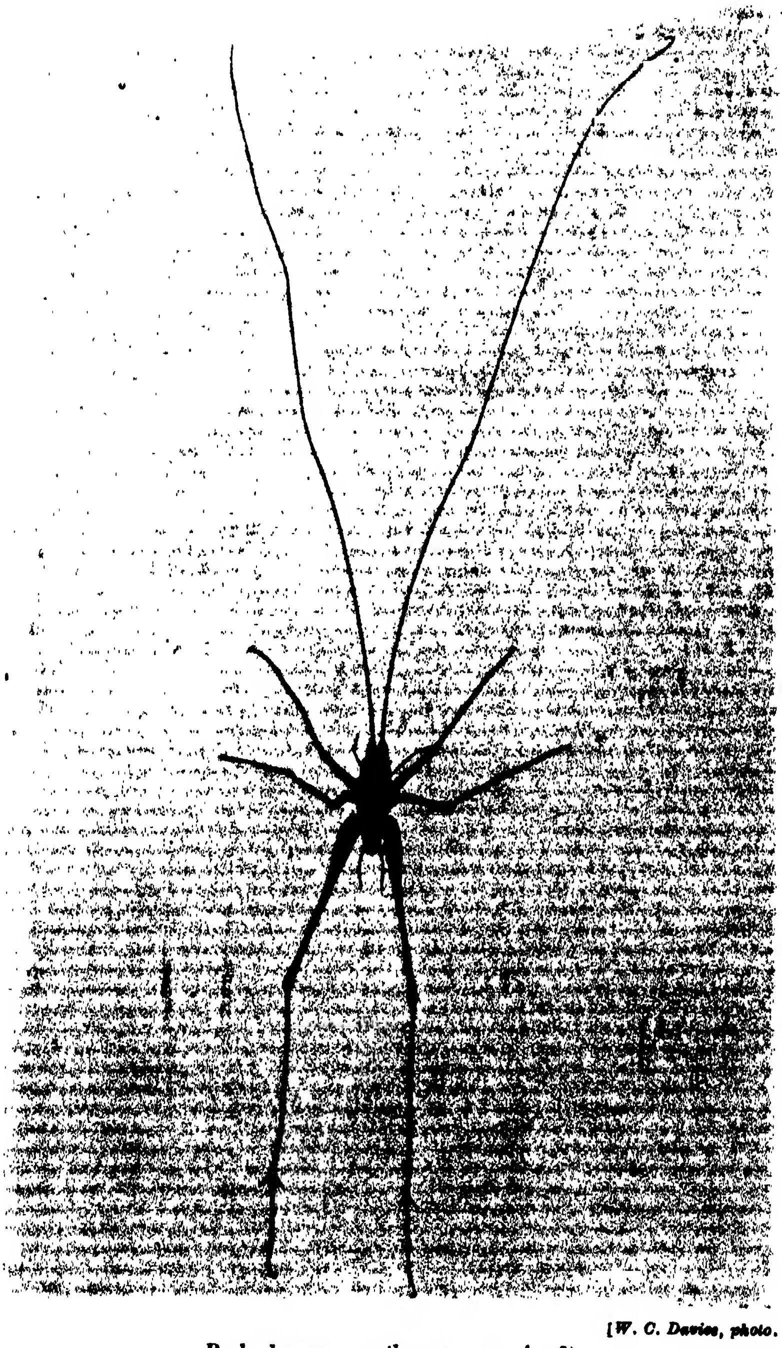
Legs: Fore legs—femur 25 mm., tibia 26 mm., tarsus 17 mm.; middle leg—femur 23 mm., tibia 26 mm., tarsus 16 mm.; hind leg—femur 51 mm., tibia 62 mm., tarsus 24 mm.

Abdomen, 9 mm. long; cerci, 9·5 mm.

Total length of specimen from tip of antenna to end of hind leg when placed in natural position, about 305 mm., or, roughly, just over 12 in.

Locality.—Waitakere Ranges, north of Auckland; February, 1923.

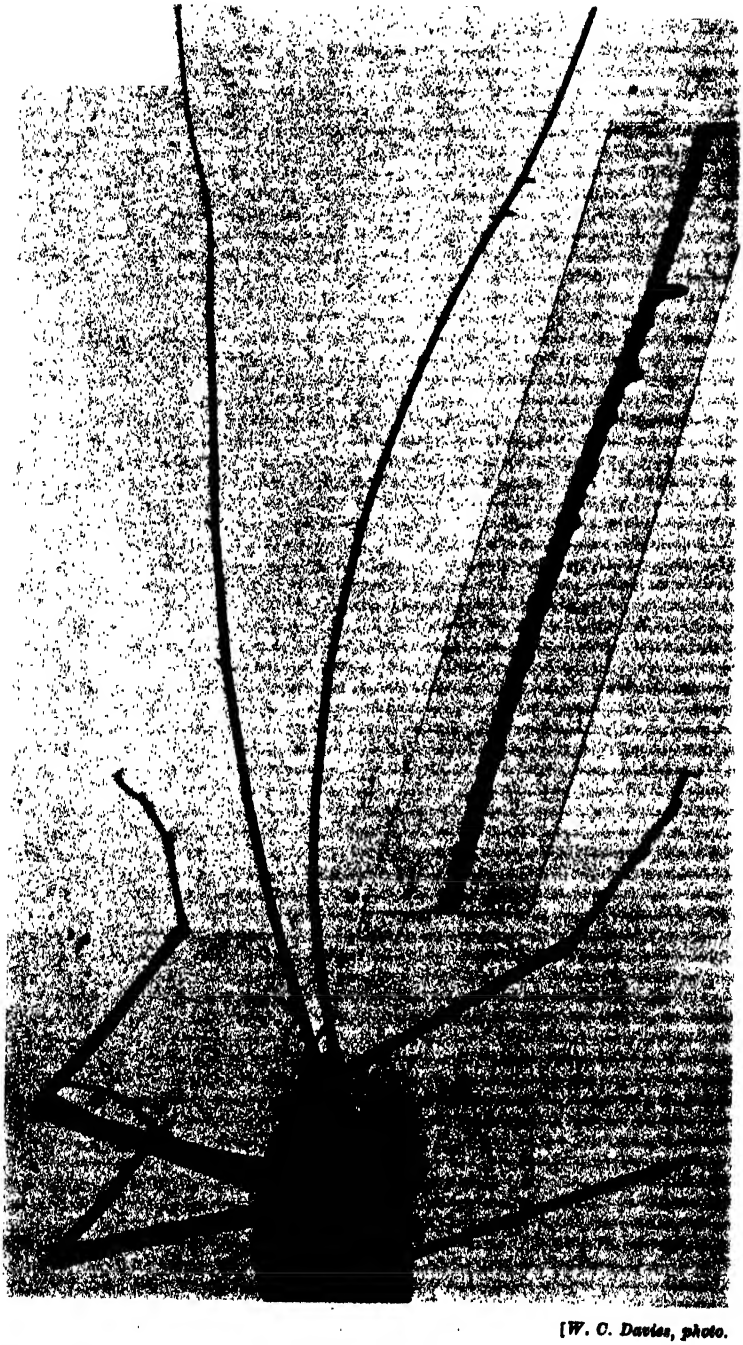
Types.—Holotype and paratype males in Cawthron Institute collection. The measurements given are those of the holotype male; the paratype is about the same size, but has the knee-joints of the middle and hind left legs deformed.



[W. C. Davies, photo.

Pachyrhamma acanthocera n. sp. (× [illegible]).

Face p. 422.]



[*W. C. Davies, photo.*

Pachyrhamma acanthocera n. sp. (× 2); showing spines on antennae (with inset enlargement).

Forest-floor Covering and its Life.

By R. E. R. GRIMMETT, M.Sc., Chemistry Laboratory, Department of Agriculture, Wellington.

[*Read before Wellington Philosophical Society, 27th August, 1924; received by Editor, 5th December, 1924; issued separately, 10th April, 1926.*]

NATURE AND VARIATIONS OF THE COVERING.

IN almost all forests, " bushes," or even shrubberies—at any rate, in New Zealand—there is present above the surface of the solid ground a layer, more or less thick, and varying greatly in texture and composition, of flowers, leaves, twigs, and other debris undergoing decomposition. It is to this layer, grading upwards, in a typical case, from " humus " through " mould " to partly-disintegrated and finally newly-fallen and quite-undecayed fragments, that the term "forest-floor covering" is here applied.

At first sight it might appear to be just so much litter of no practical importance, which in a cultivated forest might be raked up and burned. This, however, would be quite an erroneous idea, for its functions in the economy of the natural forest are various and far-reaching. Before considering these, however, a glance may be taken at the covering itself. It varies greatly from place to place in the same forest. Here it is a foot or more in thickness, there but an inch or less; in one place it is covered with " filmy ferns " and mosses, in another bare, loose, and dry; while its constituent fragments may vary from logs to tiny leaf-fragments. Yet it has two constant characteristics: it is all resting passively on the ground, and it is all undergoing disintegration and decay.

Different types of forest have different floor-coverings. This is due largely to the nature of the debris falling on to the floor, but differences of situation, climate, and moisture all induce corresponding differences in the floor-covering. That of a swamp forest will often be thick and peaty, while that of a hillside forest will often be thin, loose, and well rotted beneath. The age of the forest also makes a difference, old forests usually having thicker mould than young ones. Many other factors doubtless contribute to cause the differences observed—such as the chemical and mechanical composition of the soil. An example of this has recently been recorded in *Nature* by J. B. Farmer, who found that in certain English woodlands real leaf-mould of any thickness formed only where the surface soil was of a sandy or gravelly character; whereas where it was of a heavy, especially calcareous, nature the leaves simply rotted down and evaporated, so to speak, by the next year. He attributes this to the increased activity of bacteria in the presence of calcium carbonate causing decomposition, mainly to carbon dioxide and water. In this case the determining factor seems to be the degree of acidity of the soil. It is also possible that the increased supply of lime salts in the one case greatly aided the activities of the earthworms, to the proper digestive processes of which animals this element in fair amount is a necessity. Thus not only may the bacteria have been able to work upon the debris more rapidly, but this process may have been aided and abetted by the earthworms.

According to Colville (1), true leaf-mould is alkaline, due to the residual lime (carbonate) after the organic acids have been washed out, evaporated, or otherwise dissipated. When one year's leaf-fall is not converted into

leaf-mould (alkaline) by the following year, the process may be suspended by the leaching into it of acids from the freshly fallen leaves, and the removal of lime salts by the roots of plants, and a condition of permanent acidity result. The product in this case is not true leaf-mould, but a substance called "upland peat" because of its resemblance to bog peat. It is defined as "a nonpaludose deposit of organic matter, chiefly leaves, in a condition of suspended and imperfect decomposition and still showing its original leaf-structure, the suspension of decomposition being due to the development and maintenance of an acid condition which is inimical to the growth of the micro-organisms of decay."

Functions of the Covering.

Turning to the functions of the debris covering, we may consider them from two aspects, the chemical and the physical.

Chemical.

As plants grow they abstract from the soil certain elements which are present normally in rather small amount. These are distributed to all parts of the plant, and, although some of them are partly reabsorbed into the body of the plant before the leaves fall, a good deal is retained by these organs when they die and are shed. Also, when a branch or a whole tree dies, material is locked up inside in a form that cannot be directly utilized by the higher plants. Hence in time the soil would become depleted were no process of disintegration and decay of debris, with liberation of plant-foods, occurring. It is mostly in the debris stratum on the forest-floor that this transition takes place. Many organisms, as we shall see, take part in it, besides some perhaps purely chemical changes, such as direct oxidation. At the bottom of the layer much of the material is in a form suitable for utilization by plants, and fresh material is always working down as the old becomes decayed, oxidized, and absorbed in the soil.

Colville (1) remarks: "In soils poor in lime, trees and other plants constituting the vegetative mantle of the earth may be regarded as machines for concentrating lime at the surface of the ground. The lime is drawn up by the roots in dilute solution from lower depths, is concentrated in the foliage, and the concentrate is transferred to the ground by the fall and decomposition of the leaves."

There is another aspect, somewhat more obscure. It is known that bacteria are of enormous importance to the fertility of the soil, especially in relation to what is known as the "nitrogen cycle." Some fix free nitrogen from the air, others render nitrogen available in the soil from otherwise unavailable sources, while these and others may under other conditions use up and so diminish the supply of nitrogen available (2). On the whole, however, their activities are beneficial, and at present, at any rate, are certainly indispensable. Now, to do this work they require a source of energy, which is most easily obtained from carbohydrate material. This, in the forest, is almost all supplied by the floor-debris. A point of interest in New Zealand forests is that many of the timber-trees bear on their roots very numerous nodules of the size of small shot and smaller, and these may be found in enormous numbers throughout much of the more decayed portion of the mould. Though their nature is disputed,* whether they

* See article by J. S. Yeates in July, 1924, number of *Journal of Science and Technology.*

be comparable to the nodules on the roots of legumes which house special nitrogen-fixing bacteria, or whether they be purely of fungal origin, it is suggestive that they occur in such numbers where the supply of carbohydrate is great. It may be that this is essential to their well-being, and therefore almost certainly to that of the trees.

Physical.

The humus supplied by the decay of this debris is of great value in bringing about a good physical texture of the soil. Every one knows this to be necessary for cultivated soils, and it is no less true for forest soils. It lightens the soil, making the penetration of roots easier. It also makes the soil warmer and more equable; more porous, allowing greater penetration of surface water; and more absorptive, thus causing greater retention of moisture. In this way the bad effects of drought are ameliorated and floods are greatly reduced.

The net result is that soils of all types of original texture, from heavy clay to sandy and gravelly soils, tend to become more uniform in texture and better adapted for a timber covering. For purposes of regeneration the soil is now better adapted than in the original condition, for seedlings grow much more easily in it than on hard soil.

ANIMALS OF THE FOREST-FLOOR.

Having considered the forest-floor covering itself, it may now be considered from the point of view of its suitability and use as a dwelling-place, shelter, ambuscade, and source of food for the individuals of a large and varied animal community. That this community exists is easily verified. One has only to disturb the leaf-mould or turn over a log, and "hoppers," centipedes, spiders, insects, and all manner of creatures scatter in every direction. Their invisibility under ordinary conditions is partly due to the form and colour of those which live on the surface resembling their surroundings, but in the case of the great majority is due to their manner of life, for these are the Cryptozoa—animals which spend their existence burrowing in dark crannies and tunnels of the under-strata of the mould and in the soil itself, completely hidden from cursory view, but nevertheless carrying on great and innumerable activities. It is the nature of these activities and the animals responsible for them that are now to be considered.

Method of Study.

There are two ways of seeking information on this subject. The one may be called the qualitative or field-naturalist method. This consists in making excursions to as many types of forest as possible at all times and seasons, turning over logs, mould, and stones, and noting the species of animals occurring, their frequency, and distribution. This is an excellent method, and has been adopted by Shelford (3) in the United States with great success, and by many naturalists in New Zealand. It suffers from several serious defects, however. In the first place, few can pretend to such a detailed knowledge of all the many forms of animal-life occurring in this situation as to attempt to identify by sight more than those belonging to one or two orders at the most; and, even if specimens are collected to be identified by specific authorities, of all those appearing new and unusual to the investigator many are missed for lack of knowledge sufficient to

pick out the small details by which an expert separates many of the forms so similar in general appearance. Again, it is difficult to gain a true idea of the relative numerical importance of the various elements in the fauna, as one is inclined to give more notice to those that are most aggressive in their activity, or are largest, or most evenly distributed. Many small or protectively-coloured species are liable to be overlooked, and there are various minor disadvantages.

The other method, which was mainly adopted by the writer, is from time to time to take representative samples of the forest-floor, carefully sort and look over them, and pick out and preserve all the animals occurring. In this way a truer idea can be obtained of the identity and distribution of the animals, and various numerical and seasonal relationships shown. However, there are disabilities in this method also. The great local variations in the floor-covering, the difficulty of knowing to what depth to go, and the presence of large fragments like logs make if difficult to get a really representative sample. Then, as bright sunlight must be used when picking over the sample to stir otherwise invisible animals into activity, and a large amount of time is consumed in the operation, samples cannot be taken as frequently as is desirable. Moreover, almost nothing is learnt of the habits and life-histories of the members of the animal community; that must be gained by careful and patient observation in the forest itself.

While, therefore, relying mainly on the latter method, the writer endeavoured to apply the former as much as possible.

The floors of two types of forest only were studied in detail. These were respectively mixed rain forest, represented by Chapman's Bush (adjoining Wilton's Bush, Wadestown), and southern-beech forest, represented by that on the hill above Days Bay. An area of about 50 yards square was marked out in each locality, and representative samples taken from these once a month from March to September, inclusive, 1923. Ten small samples, each 9 in. square, were taken monthly from each locality and combined to make two large samples. These were sorted over and all the large animals, together with sticks, &c., removed, the remainder thoroughly mixed and divided evenly till only one-eighth was left. This was then very carefully sorted over till all animal-life visible in the brightest sunshine was removed. No doubt a certain number of the more minute were inevitably left behind, but those found were surprisingly numerous. The number picked out from the small sample multiplied by eight, plus the number picked out at first, gave a rough estimate of the number originally present. All the specimens were identified as nearly as possible with the ready aid of various authorities and the results tabulated. Though too long to reproduce these here, a summary is given at the end of this article of the species mainly occurring. Only the commoner species, generally speaking, were identified with anything like certainty. This was partly due to the fact that the literature on many of the groups is somewhat scattered and difficult to obtain, while many of the more obscure species of the less-studied groups are not yet described.

Relation of Forest-floor Animals to their Environment.

In nature the great majority of animals may be said to fall into one or other of three classes, according to the way in which they are adapted to their environment. The first comprises those which show their colours openly, making no attempt at concealment. These are the possessors of some special power or qualities which give them racial protection: such as

a high rate of reproduction; some quality rendering them distasteful or inaccessible to most other animals—for example, the hairy caterpillar of the magpie moth; great size and strength; or the possession of armour.

In the second class are those animals which, by dissimulation of some kind or other, seek to escape observation either for purposes of offence or defence. The great majority of animals living exposed to the light come under this heading.

The third class neither publish their existence nor disguise themselves, but live in hidden stations away from the light. These, as before mentioned, are sometimes called Cryptozoa. Having external protection in the form, say, of some part of a plant, a decaying log, the soil, o · even, in the case of parasites, of another animal, and being consequently more or less in darkness, they have no use either for protective colouring or form. As a result colour is more or less dispensed with, and the form which approximates to that of the greatest utility in such situation is adopted. Generally speaking, this form is cylindrical, with legs and other appendages reduced to the minimum size consistent with use (4). This is well illustrated in the case of the earthworm and of the burrowing larvae of certain insects—for example, the wood-borers.

These classes are not, of course, hard-and-fast. Many animals are on the border-line between one and another, or may change from one to another at different stages in their life-histories. But in broad outline they indicate definite tendencies in animal-life, and in many cases there is no doubt as to where we should place a given animal.

Thus the great majority of the inhabitants of the forest-floor debris are dull-coloured creatures with few peculiarities of shape or structure and of a distinctly retiring disposition. Most of them shun bright light—they run from it on every occasion; in other words, they are negatively phototactic. Most of them like a considerable degree of moisture, and gradually retreat farther from the surface during dry weather. In these two respects, however, there is a great degree of difference observable between the various members of the forest-floor community. Thus *Parorchestia sylvicola* (the ordinary bush-hopper), most of the earthworms, and the long slender centipedes which feed largely upon them (species of *Zelanophilus*), and in general the pale translucent-looking animals, are very sensitive to light; while many of the spiders, mites, beetles, and in general dark or well-marked and opaque-looking ones like the large woolly ground-spiders *Hexathele hochstetteri* and *Porrhothele antipodiana*, do not fear bright light nearly so much, and in consequence live near or on the outer surface of the floor-debris. Similarly, those with hard (chitinized) integuments usually require less moisture than the thinner-skinned species, and live frequently in drier situations. Earthworms, the larvae of some insects, hoppers, woodlice (Isopods), and many others, can only thrive where there is a considerable degree of moisture.

Although all living together in the same medium, the food habits of the animals under consideration present almost all possible variations. These may, however, be summarized under three headings. There are those which live on the medium itself—in other words, on decaying vegetable and animal remains (saprophagous animals); those which eat their fellow denizens, or make predatory raids into the strata above (arboreal) or below (subterranean) that in which they live (carnivorous animals); and those which feed upon roots, leaves, or other parts of plants (phytophagous). There are no sharp boundaries between these classes, as many of the

animals are omnivorous, or change from one class to another at different stages in their life-histories. The majority, however, fall either exclusively or predominantly into one or other of the classes.

Saprophagous Animals.

As regards the saprophagous animals, in the first place the fresher fragments of the debris are eaten by many of these animals. Much indigestible material is often thus ingested for the sake of the small digestible portion it contains. The latter, consisting of certain protein, carbohydrate, and some of the mineral matter, is abstracted, and after use by the animal ultimately returned to the soil in a condition readily available for plants. The woody undigested residue passing from the animal as faeces is in a finely pulverized condition, very suitable as a medium for fungal and bacterial action, by which means it is ultimately broken down into its simpler constituents. The earthworms, daddy-long-legs larvae (Tipulids), and "hoppers" (*Parorchestia sylvicola*) illustrate this process. Again, by constant boring and burrowing operations in search of food, many animals pulverize the undecayed fragments as well as keeping them open to the air and well turned over, thus aiding bacterial action. Finally, in the case of earthworms especially, a great deal of the surface debris is carried fairly deep below ground in burrows, and earth is brought to the surface, thus causing a gradual mixing of the whole, with a hastening of the process of decay and an enrichment of the lower layers of the soil. In this way less nitrogen is lost than would otherwise be the case (5).

The following quotation from Colville (1), whose article has come to my notice only since the above was written, is interesting in this connection :—

"The chief agents in the decay of leaves are undoubtedly fungi and bacteria. There are other agencies, however. that contribute greatly to the rapidity of decay. Important among these are earthworms, larvae of flies and beetles, and myriapods, or thousand-legged worms. Animals of all these groups exist in myriads in the leaf-litter. They eat the leaves, grind them, partially decompose them in the process of digestion, and restore them again to the soil, well prepared for the further decomposing-action of the microscopic organisms of decay.

"The importance of earthworms in hastening the decay of vegetal matter was pointed out long ago by Darwin. The importance of myriapods, however, as contributing to the formation of leaf-mould, has not been adequately recognized. In the cañon of the Potomac River, above Washington, on the steeper forested talus slopes, especially those facing northward, the formation of alkaline leaf-mould is in active progress. The purer deposits are found in pockets among the rocks, where the leaf-mould is not in contact with the mineral soil and does not become mixed with it. The slope directly opposite Plummer's Island is a good example of such localities. Here during all the warm months the fallen leaves of the mixed hardwood forest are occupied by an army of myriapods, the largest and most abundant being a species known as *Spirobolus marginatus*. The adults are about 3 in. in length and ½ in. in diameter. They remain underneath the leaves in the daytime and emerge in great numbers at night. On one occasion a thousand were picked up, by Mr. H. S. Barber, on an area 10 ft. by 100 ft., without disturbing the leaves. On another occasion an area 4 ft. by 20 ft. yielded 320 of these myriapods, the leaf-litter in this case being carefully searched. Everywhere are evidences of the activity of these animals in the deposits of ground-up leaves and

rotten wood. Careful measurements of the work of the animals in captivity show that the excrement of the adults amounts to about ⅛ c.c. each per day. It is estimated on the basis of the moist weight of the material that these animals are contributing each year to the formation of leaf-mould at the rate of more than 2 tons per acre."

Other Forms of Life.

Although they cannot be considered in detail here, brief mention must be made of other forms of life present in the debris stratum. Among these are the microscopic unicellular animals, the Protozoa, whose activities are mainly concerned with limiting the number of bacteria; and the much larger composite animals belonging to the same phylum or natural division, the Mycetozoa, sometimes called "slime-fungi"—curious thin, jelly-like plates of living matter which creep slowly over damp rotting material, feeding both saprophytically upon it and also digesting any small organisms in their course (2). Then, besides ferns, mosses, and algae, which, being green plants, do not much concern us in this connection, there are present a large number and variety of fungi. These feed saprophytically and help to a great extent in breaking down the debris, as well as serving as food for much of the animal-life.

It is well that all the agencies that assist in bringing about the dissolution of the fallen trees of the forest cannot operate in the artificial environment of our wooden dwelling. The main factor controlling most of them is perhaps the absence of moisture. In the forest there is a natural sequence, commencing probably with the wood-eating beetles and other insects (huhu grubs, for instance), which, having tunnelled the dead trunk in all directions and reduced much of the material to powder, leave the field clear for tipulid larvae, millipedes, amphipods, and others; and these again, having served their turn, give place to the final scavengers, the earthworms. It must not be thought, however, that this is a simple linear process of one animal living on another's faeces, for, throughout, bacteria and fungi are continually transforming these remains, as well as building part of them into their own bodies, the latter in turn being used as food by subsequent denizens.

Life Strata in the Forest.

The debris-dwelling animals have so far been considered as a separate community. It remains to consider them in relation to the rest of the forest inhabitants and the life of the forest itself.

The animals of the forest dwell in three main strata, each exhibiting certain characteristics. These strata are—(1) The subterranean stratum; (2) the forest-floor-debris stratum; (3) the arboreal stratum. In each of these strata live animals exhibiting the three main types of feeding-habit enumerated previously, but the relative abundance of each kind of food in each of the strata determines to a great extent the relative proportions of these animals present. Thus in the soil itself roots and fine scattered food-particles left in the decay of plant-remains form the principal source of food; in the debris stratum dead material and the life it supports (abundance of saprophagous animals) are the principal supply; while in the arboreal stratum food is abundant in the form of foliage and other plant-tissues, and this is reflected in the large number of plant-feeding animals, which, again, support a predatory population.

None of the communities of these three strata is, however, independent. Each is necessary to the others, and depends, in part immediately and in part ultimately, upon them for its existence. Thus in the subterranean stratum the rather fixed and well-distributed food-material is mostly eaten by slow-moving burrowing animals, which usually simply eat their way through the soil, having little need of special-sense perceptions to guide them, leaving to their digestive apparatus the task of separating the assimilable portions. The obstacles in the way of carnivorous animals gaining a living in this stratum are, however, considerable. They must either be endowed with a special sense enabling them to track their victims, or be contented to turn over a relatively enormous amount of material in a random search. Consequently we find carnivorous animals in the minority.

In the forest-floor stratum conditions are very different. The most abundant food-supply is the litter of decaying leaves, stems, and other vegetable material, which is generally fairly loose; it thus supports not only a numerous saprophagous population, but also affords good concealment and opportunities of ambush and chase for a large and varied predatory one. Living vegetable material is here at a minimum, consequently also the animals which feed upon it. This stratum, which lies in a position of vantage midway between the other two, and offers abundant opportunities for concealment, is the habitat of a large number of the carnivorous animals of the forest. These obtain their food not only from the stratum in which they live, but also at the expense of casual immigrants into their stratum—such, for example, may be the fall of insect-larvae from trees, their descent into the ground to pupate, the migration of nocturnal animals for concealment by day, or the emerging of insect adults from the subterranean stratum. Some, such as many opiliones and spiders, augment their food-supply by incursions (chiefly nocturnal) into the arboreal stratum. Thus they probably exercise a considerable degree of control over the phytophagous species, which are largely harmful. This is perhaps especially the case with wood-boring insects. Arboreal carnivorous species (excepting the parasitic ichneumon wasps) mainly confine their attention to external plant-feeders; but, in accordance with their habit of living in confined surroundings, such carnivorous units as centipedes, spiders, and opiliones of the forest-floor stratum may be found in tunnels and crevices in living wood, and the last have actually been observed by the writer eating wood-boring insect-larvae.

Quite a different aspect of their role in the forest life is their use as food by a large number of the forest-dwelling birds. Their number being great, and not so dependent on season or weather as in the case of the arboreal population, they form an important winter food reserve, though many of them are less palatable than the leaf-eating grubs and the ripe berries obtainable at other seasons.

Finally, it may be said that, as they form an integral and natural part of the general life-community of a forest, it is clear that both in the above and in many more obscure ways they must contribute greatly to that healthy position of equilibrium which obtains in its maturity.

Description of Forests and Localities.

Beech Forest.

The first of the two localities studied is a portion of forest, approximately 50 yards square, lying on the south-west aspect of the beech-forest-covered hills on the east side of Port Nicholson, near the top of the ridge behind

the Days Bay pavilion. The altitude is about 1,000 ft. The forest is the original southern-beech association of these hills, and is composed of the following trees :—

Forest-trees : *Nothofagus Solanderi*, *N. fusca* (both very plentiful), *Weinmannia racemosa* (very common), *Metrosideros robusta*, *M. florida* (liane), *Elaeocarpus dentatus*, *Podocarpus ferrugineus*, *Griselinia littoralis* (small tree), *Suttonia salicina* (small tree), *S. Urvillei*, *Coprosma grandifolia* (small tree), *Knightia excelsa*, *Drimys axillaris* (small tree).

Undershrubs : *Coprosma foetidissima*, *C. Colensoi*, *C. lucida*, *C. rhamnoides*, *Cyathodes acerosa*, *Leucopogon fasciculatus*, *Dracophyllum Urvillianum* var. *filifolium*, *Nothopanax Colensoi*, *Cyathea dealbata*.

Floor : *Polypodium grammitidis*, *Cyclophorus serpens*, *P. Billardieri*, *Hymenophyllum demissum* (with several other species, very common), *Trichomanes reniforme* (common in patches), *Blechnum capense*, *Lindsaya viridis*, *Asplenium flaccidum*, *Dianella intermedia*, *Astelia nervosa*, *Pterostylis Banksii*, *Gahnia* spp., *Uncinia filiformis* and other species.

The forest-floor is covered in many places by a dense growth of filmy fern (*Hymenophyllum* spp.) and kidney-fern (*Trichomanes reniforme*), while mosses, liverworts, and fungi are present in patches. Undershrubs are present but are not closely spaced. Above the ground-level is in most cases 1 in. to 3 in. of decayed vegetable matter, held together with a network of fine roots, while above this is a fine layer of loose debris (leaves, twigs, &c.). The subsoil, which comes close to the surface, is mostly a greywacke rock.

The situation is on a fairly steep slope, and the dense foliage of the beeches combined with the southerly aspect renders it somewhat darker at the ground-level than is the case in the second locality. Owing to the above factors and its altitude (1,000 ft.) it is also considerably colder. The exact conditions are given in connection with each sample taken.

Tawa Forest.

The second locality is a similarly-sized portion of forest in the middle of the remnant of a formerly more extensive rain forest to the south-west of Wadestown, known as Chapman's Bush, now a portion of the Wellington Corporation reserve. This is largely a tawa forest. A list of the plants occurring in this limited area as given by Mr. B. C. Aston is as follows :—

Forest : *Beilschmiedia tawa*, *Elaeocarpus dentatus* (hinau), *Olea montana*, *Metrosideros robusta* (rata), *Knightia excelsa* (rewarewa).

Small trees and shrubs : *Pennantia corymbosa* (kaikomaka), *Metrosideros florida* (liane), *M. scandens*, *Griselinia lucida* (epiphyte), *Rhipogonum scandens* (liane), *Parsonsia heterophylla* (liane), *Astelia Solandri* (epiphyte), *Suttonia australis*, *Coprosma grandifolia*, *C. robusta*, *C. crassifolia*, *C. areolata*, *C. rhamnoides*, *Macropiper excelsum*, *Geniostoma ligustrifolium*, *Brachyglottis repanda*, *Cyathea dealbata*, *Myrtus bullata*.

Floor : *Dryopteris velutina*, *Blechnum filiforme* (epiphyte), *Asplenium lucidum*, *A. flaccidum* (epiphyte), *A. adiantoides* (epiphyte), *Polypodium Billardieri*.

The material of the forest-floor covering is generally much looser, less decayed, and less matted by roots than is the case in the first one. The altitude is only about 100 ft. above sea-level. Owing to less density in the

tree-foliage, and its situation on a gentle slope facing north, it is also considerably lighter and warmer than the first locality. Ferns are not so numerous on the forest-floor, but there are patches of the climbing-fern *Blechnum filiforme*, and several others. Mosses, lichens, and fungi are also comparatively scarce, and in many cases dry debris alone forms the upper surface of the floor.

Though surrounded by forest, this area is less removed from settlement than the former one.

Date of taking Samples, and Weather Conditions.

(A = beech forest; B = tawa forest. The figures in the second column refer to the numerical order in which the samples were taken.)

1923.		
Mar. 17.	1A.	Ground damp from rain some days previously; day bright, with clouds.
Mar. 23.	1B.	Ground damp, rain in morning; day cloudy.
April 13.	2B.	Ground dry, no rain for some days; sky overcast.
April 20.	2A.	Ground very dry, no rain for over a week; day bright and hot.
May 11.	3B.	Ground wet after week's rain; day dull; some rain, warm.
May 18.	3A.	Ground wet, rain during morning, sunny at noon when sample taken; warm.
June 13.	4B.	Ground very wet from rain during week previous and in morning; sunny at noon, warm.
June 20.	4A.	Ground wet, but weather fine till midday, when cold rain commenced. Sprouting noticeable in seeds and roots of sample.
July 13.	5B.	Ground damp; weather cold but fine.
July 20.	5A.	Ground very wet; day cold and showery.
Aug. 13.	6B.	Ground damp; day sunny, warm.
Aug. 17.	6A.	Ground fairly dry; day fine and warm.
Sept. 7.	7B.	Ground wet, rain in morning; day warm and sunny.
Sept. 14.	7A.	Ground fairly dry; day warm and humid.

Fauna of the Forest-floor Covering.

Summary.

1. *Turbellaria.*—Land planarians (or flatworms) do not appear to be represented to nearly the extent that might be expected. Many of this group, however, are not at all or only partially cryptozoic, and the majority appear to be rather restricted as to habitat. Thus some species may be found in damp portions of wood, or under the bark of decaying logs, which, owing to the difficulty of including them in a representative sample, and also to their being frequently the loci of quite local concentrations of the forest fauna, were perforce neglected in the present study. Those planarians found, however, are fairly distributed among the samples from both localities.

Geoplana sanguinea, the species occurring in the greatest number, was found three times in samples from each locality. It is one of the dullest and least diversified in colour of our native planarians, and in this respect agrees with the more typical Cryptozoa, with which I think it may be included.

The other species found were *G. subquadrangulata*, *G. spectabilis*, and *G. agricola*. They are perhaps more in the nature of casual invaders. All are carnivorous.

2. *Oligochaeta* (*Earthworms*).—These occurred in considerable numbers in all the samples. In general they are more numerous in the beech-forest series than in the rain forest. Their numbers fluctuate rather widely, conditioned probably to a large extent by the state of the debris as regards moisture content, which in turn is greatly influenced by the immediate weather conditions. It is well known that earthworms come nearer to the surface in wet weather: thus in the forest occurs a temporary invasion from the more subterranea pnpoulation into that of the surface stratum. In the September sample from Chapman's Bush locality occurs a great increase, perhaps in a large measure of this nature. The bushes were actually dripping water when the sample was taken. There seems to be no variation of a progressive kind indicated throughout the period.

The soil in Chapman's Bush is much deeper and more loamy than that of Days Bay ridge, a fact which is probably correlated with the larger number and, it may be stated, the much larger size of the earthworms present.

Species of *Maoridrilus* and of *Octochaetus* were found in both localities; *Diporochaeta* spp. occurred only in the Days Bay samples and *Neodrilus* spp. only in the Chapman's Bush ones. A considerable number of minute worms could not be identified.

The members of this group are typically saprophagous.

3. *Crustacea.*—The Crustacea are among the most completely cryptozoic and most typical members of this type of association. This is especially true of the amphipod *Parorchestia sylvicola*, which appears to be distributed in the floor-debris of almost all types of forest and scrub associations in New Zealand. It is also distributed rather evenly, and its numbers do not appear from field observations to fluctuate much throughout the year. The adults were not found to fluctuate much in number in either locality throughout the period. Their widest variations are between 20 and 66, which is not so great considering the many arbitrary factors involved. The young show, as might be expected, greater variation.

There appears to be indicated a rather regular monthly alternation between high and low numbers of the young. Possibly this is connected with some brood-production period, but the figures are insufficient to generalize upon.

The males of this species are known to be rather rare. All the specimens collected were therefore determined for sex, the large flattened front legs of the male being, on the suggestion of Dr. Chilton, used as a guide. It was found that in a total of 383 specimens from the beech-forest locality, 43, or 11·2 per cent., were males, while in a total of 333 from the tawa forest no males were discovered, though each specimen was carefully examined with a dissecting-lens. Moreover, the males in the former were fairly evenly distributed throughout all the samples. It would thus appear that males are extremely rare or are not produced in the lower-altitude forest during this portion of the year. Temperature, dependent on altitude, is suggested as the environment factor most likely to be involved.

This species is typically saprophagous.

Isopoda: Among isopods (slaters, or woodlice) much greater differences in distribution are apparent. They are very much more abundant in the Chapman's Bush samples than in those from Days Bay, the totals being respectively 491 and 86 for the period, while the species present seem each to be restricted to one or the other locality. *Trichoniscus* spp. occur in both localities, while *Philoscia* spp. (*pubescens*) occur only in the Chapman's Bush samples. Species identified were *T. thomsoni*, *T. phormianus*, *P. pubescens*, and a species of *Cubaris*.

There is noticeable in the Chapman's Bush figures a considerable increase in the number of isopods present during the winter months of June, July, and August, with a slight decrease in September. The maximum occurs in July. This is more noticeable in the actual specimens, which are mostly mature and of large size during these months, while they are much smaller in the preceding months. It is probably the dampness of the debris, due to frequent rains and little evaporation, that is the chief factor in the case.

The isopods are both saprophagous and phytophagous.

4. *Chilopoda* (*Centipedes*).—The chief representatives of these typical Cryptozoa were *Anopsobius neozelanicus* and *Paralamyctes validus* (scarce) among Lithobiomorpha, and various species of *Zelanophilus* and *Zelanion* among the Geophilomorpha. The first of these two types was almost equally common in both localities; the second is considerably more common in the beech-forest samples, the individuals also being larger. There appears to be a tendency to increase in numbers and in size of the Chilopoda during the winter months. The Scolopendromorpha are decidedly rare, being represented by only two individuals collected.

The members of this group are all carnivorous.

5. *Diplopoda.*—There being no systematic work on the New Zealand Diplopoda, these typical saprophagous and phytophagous Cryptozoa are classified in the tables only under families. Of these, various species—Julidae, Polydesmidae, and Siphonphoridae—occurred rather commonly The last appear to be represented more commonly in the beech-forest samples (by a species of *Siphonophora*); the others show little difference in this respect. No progressive changes in the population appear to be indicated.

All the above groups are whole-life-cycle Cryptozoa typical of this type of association in general. With the exception of certain members of each, this cannot be said of the succeeding groups.

6. *Insecta.*—Among Insecta a very miscellaneous collection is represented.

Collembola ("springtails") are noticeable by their small numbers, mostly occurring in Chapman's Bush samples.

Thysanura were not found. This is decidedly surprising when compared with the debris-fauna of European pine forests as investigated by Pillai (6), who states that this group and Nematodes are by far the largest ones represented. From field observations the writer can add that this appears to apply as regards Collembola to pine forests in New Zealand.

It is worthy of note in passing that no Nematodes (thread- or round-worms) large enough to be detected with the unaided eye were found in any of the samples. Some water infusions of portions of the material, however, revealed a few microscopic ones.

Orthoptera: With the exception of some small undescribed forficulids ("earwigs") and an odd cockroach, few were found. The rarity of wetas is noticeable; but the same consideration applies here as in the case of planarians. Identified were * Outilia sidilotti*, *Onosandrus pallitarsis*, and *Argosarchus horridus*.

Lepidoptera (moths) and Diptera (two-winged flies), where found, are almost certainly casual immigrants. Only an odd specimen or so occurred, including a small Simulian and a Cecidomyiid.

Hemiptera (bugs): Certain of these are typical inhabitants of leaf-mould, notably *Metagerra obscura* (mainly in beech forest), which is widely

distributed. Their numbers are not relatively large. *Coelostomidia zealandica*, *Targarema stali*, *Hahnia australis*, a Myodochid nymph, and specimens of a new genus of Cicadellidae also occurred.

Hymenoptera: In this order occur the most anomalous differences found in the investigation. Ants, being colonial, are not amenable to any ordinary method of sampling. *Prenolepis longicornis* is the species most commonly found, and in some samples constituted an overwhelming majority of the fauna. It appears to be more common in samples from Days Bay than in those from Chapman's Bush. Other ants were *Ponera castanea* (rare), *Aphaenogaster antarcticus*, and a species of *Formica*.

A small ichneumon found is perhaps parasitic on one of the insect larvae of the association.

Coleoptera (beetles): Those that are not perhaps casual invaders are probably the Staphylinidae (including *Quedius* sp.), Pselaphidae (*Sagola*, *Euplectus*, *Gastrobothrus* spp., and others), and Carabidae (*Agonochila binotata*, *Oopterus*, and *Metaglymma* sp., and others unidentified) among carnivorous forms; *Bitoma*, *Enarsus*, and *Pseudopatrum* spp. among the saprophagous ones; and weevils among the phytophagous ones.

Sagola occurs only, and rather commonly, in the Days Bay samples; various "carabs" also follow the same rule. The staphylinids are more common in Chapman's Bush samples; weevils are much more common in the former than in the latter.

Also identified were—(Elateridae) *Corymbites* sp.; (Dascillidae) *Veronatus* sp.; (Byrrhidae) *Pedilophorus* sp.; (Lamellicornia) *Odontria* sp., *Onthophagus posticus*; (Hydrophilidae) *Tormissus magnulus*, (Cucujidae) *Dryocora howittii*; (Heteromera) *Hylobia nubeculosa*, *Pseudopatrum tuberculicostatum*; (Longicornes) *Somatidia antarctica*; (Rhynchophora) *Phrynixus astutus*, *Phemus scabralis*, *Nonnotus* sp., and *Brachylous* sp.

Insect larvae (grubs or caterpillars) constitute a large proportion of the population. Most of the insects concerned are Cryptozoa only at this stage of their life-history. Among the carnivorous ones carabid or staphylinid larvae are present in both localities throughout. Elaterid larvae are also common. Saprophagous forms are found mainly among the Diptera. They occur commonly throughout both series. A large brown tipulid larva is particularly evident in the April sample from the tawa forest.

One species of Lepidoptera larvae is particularly common throughout the Days Bay samples, occurring to a lesser extent in the Chapman's Bush samples. It is probably a root-feeder, being always found well distributed throughout the matrix of fine roots. A great number of larvae could not be placed with any certainty.

7. *Arachnida.*—The Araneida (spiders) are represented by certain characteristic members, while others are probably only chance visitants. Of the former, *Hexathele hochstetteri* and *Lycosa umbrata* are common, the former more so during the first four months. Both are evenly distributed between the two localities, the latter species being the commoner. A large species of the family Dysderidae occurred regularly in the Days Bay samples, doubtfully in the other ones. *Clubiona peculiaris*, a very pale-cream-coloured spider, was scarce but characteristic of Chapman's Bush locality. *Sidyma angulata*, perhaps a surface-dweller, occurred at times in both. *Araneus crassus* occurred once, and a Salticid twice. Many of the small spiders are probably immature *Hexatheles* and *Porrhotheles* (*antipodiana*), though several seem to be adult micro-araneids. The members of this

group are present in only moderate numbers, but by their carnivorous habits and frequent large size exercise a considerable influence.

Opiliones (harvest-spiders) have two chief forms present—a species of *Purcellia* represented by moderate numbers, and several closely-allied species of *Triaenonyx*, most common in the rain forest. Other cryptozoic species are known to occur in both areas, but are probably more specialized, not venturing far from certain habitats. They are also mainly nocturnal in their movements. Identified were (Laniatores) *Triaenonyx coriacea*, *T. cockayni*, and (Palpatores) a species of *Macropsalis*.

Pseudoscorpions (book or false scorpions), represented by several unnamed species, are also more common in the rain forest.

Both these groups are carnivorous.

The Acarida (mites), in point of numbers, form a very large proportion of the associations of both localities. This is probably also much larger than is indicated by the tables. Considering their minute size, however, their relative importance is considerably reduced. Many species are present, but as none, or practically none, are named, any indications of genera shown are purely tentative. Beetle-mites are by far the most numerous, some being of relatively large size. The species of the Rhyncholophidae shown in the rain-forest samples is a very pretty mite of a bright-red colour, about $\frac{1}{8}$ in. in diameter. It has four or five pairs of long, stout, latero-dorsal finger-like processes, extending from the level of the first pair of legs to the posterior extremity, beset with very numerous long hairs, many of them pectinated. These intertwine, giving the animal a woolly appearance.

Most of this group are probably either parasitic or predatory. The following occurred: Oribatidae—*Oribatella* sp. (common), *Nothrus* sp. (common, especially in beech forest); Haplodermidae—several spp., Gamasoidea (several species, especially in beech forest): Troglyphidae—several species; Eupodidae—only in tawa forest (rare); and Rhyncholophidae (rare).

8. ***Mollusca.***—The Mollusca (snails) are represented by several species, chiefly of the genera *Endodonta* and *Laoma*. All are small, and none can be called common. Their food is probably derived from the low-growing herbage. Identified (tentative) were *E. biconcava*, *E. tapirina*, *E. coma*, *E. pseudoleidon*, *E. anguiculus*, *Laoma marina*, and *Lagochilus lignarius*.

Remarks.

There is nowhere any great divergence between the fauna of the two localities; all the main units are represented, and, leaving out of account the ants, to about the same extent in each locality. When we come to genera and species, however, certain of these appear to be restricted to each habitat, and, among those that are common to both, rather wide variations in numerical importance become apparent. This is in accord with expectation: the two habitats are similar in their main environmental conditions; in both cases it is the floor of a forest of considerable age practically in its primeval condition; there is no great geographical separation; and the remaining factors, except that of the plant covering, show no great variation. With the plant covering it is largely a case of substitution of one ecological unit for an equivalent or almost equivalent one in relation to the remainder of the association, but adapted suitably to the slight differences in the rest of the environment. Somewhat similarly with the animal association, substitution of one unit for a similar one occurs without affecting appreciably the character of the association as a whole.

Considerable differences occur in the composition of the faunas of each locality, as indicated by the samples taken from month to month: this

is probably due to several causes—in part to a real seasonal change, and in part to particular weather conditions. Thus the large increase in the number of earthworms in some samples appears to be largely due to wet weather immediately preceding causing them to come nearer the surface, and so be included in the sample.

Monthly Totals of Larger Taxonomic Groups.

(A = beech forest; B = tawa forest.)

Month.	Insects.									
	Coleoptera.						Ants and Ichneumons.		All other Insects.	
	Carnivorous.		Saprophagous.		Phytophagous.					
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
March ..	51	40	32	10	80	16	204	281	53	3
April ..	144	64	26	16	32	..	126	64	49	20
May ..	82	32	1	..	..	..	20	16	36	9
June ..	176	40	..	8	16	..	1,304	88	8	25
July ..	320	41	34	1	24	8	20	..	20	43
August ..	88	16	1	41	40	1	2,040	64	35	25
September ..	216	..	57	..	72	1	48	68	11	..
Total, all months	1,077	233	151	76	264	26	3,762	581	212	125

Month.	Insect Larvae.						Acarida.		Opiliones and Pseudo-scorpionida.		Araneida.	
	Carnivorous.		Sapro-phagous.		Phyto-phagous.							
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
March	62	34	97	104	17	..	264	176	11	75	34	65
April	44	12	50	32	42	6	160	481	50	88	113	59
May	20	3	..	3	11	14	73	42	10	33	78	32
June	35	43	..	70	21	10	136	169	12	67	67	47
July	88	8	35	60	53	12	640	249	44	61	36	17
August	64	44	90	80	34	18	376	96	40	173	95	78
September	48	1	24	74	29	7	272	184	32	91	66	20
Total, all months	361	145	296	423	207	67	1,921	1,397	199	588	489	318

Month.	Chilopoda.		Diplopoda.		Crustacea.		Mollusca.		Oligochaeta.		Turbellaria.	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
March ..	54	58	71	53	192	191	10	10	42	53	1	2
April ..	126	131	71	10	71	97	8	32	28	56	..	..
May ..	123	40	81	12	155	87	32	8	21	54	2	..
June ..	117	222	21	98	111	263	3	41	79	113	2	2
July ..	193	89	46	66	186	249	32	107	85	54	..	1
August ..	201	157	30	90	164	244	51	58	70	115	..	..
September	204	65	108	12	108	183	48	49	36	356	1	..
Total, all months	1,018	762	428	341	987	1,314	184	305	361	801	6	5

Monthly Totals of Larger Ecological Groups (excluding Ants).

(A = beech forest; B = tawa forest.)

Month.	Carnivorous.		Saprophagous.		Phytophagous.	
	A.	B.	A.	B.	A.	B.
March	477	450	434	411	160	29
April	637	835	246	211	131	58
May	388	182	258	156	79	31
June	545	590	211	552	48	76
July	1,321	466	386	430	129	170
August	864	564	355	570	160	102
September	839	361	333	625	160	57
Total, all months ..	5,071	3,448	2,223	2,955	867	523

Some General Considerations.

Although the present subject is really an ecological one, no attempt has been made above to deal with it in strictly ecological terms. The debris-dwellers of two types of forest were studied, and for a limited time only, in detail. Other types in various localities and at various altitudes would almost certainly reveal quite different animal associations, and these might possibly be classified on a broader basis into formations. Besides the indigenous forests, those of exotic origin certainly have very modified associations. This is certainly true of *Pinus radiata* forests, but what the quantitative relations are has not been tested. A huge field for investigation is open here, especially as many of the animals are so imperfectly known.

In the large general debris stratum of a forest the animals do not all bear an equally close relationship. Many small spheres of intimately connected activity are present. The term used by Shelford (3) for such a direct interdependence is a "consocies." The interdependence may be the result of reliance on the same specific food-supply, or it may be more in the nature of symbiant associations. Thus we might speak of the earthworm consocies as being constituted by the earthworms and the various animals, such as flat-worms (*Planaria* sp.) and centipedes (*Zelanophilus* sp.), which feed more or less particularly upon them. Again, we have the consocies constituted by the ant *Prenolepis longicornis* and the various species of Hemiptera (bugs) which are associated more or less symbiotically with it.

With regard to statistical results, the complete statement in tabular form of all the occurrences of the animals found is too lengthy for publication, but an analysis of these has been attempted and the results are given above under the headings "Monthly Totals of Larger Taxonomic Groups" and "Monthly Totals of Larger Ecological Groups."

The uncertain position of the Formicidae, which form a large proportion of some of the totals, prevents any close comparisons. Where present in excessive numbers they may also have reduced the numbers of other animals by the time the latter could be separated. The numbers of those classified as "carnivorous" are considerably augmented by the mites, which are small and only partly carnivorous. Their irregularity in numbers is also responsible for the larger fluctuations observable in this group.

Taking into account these two considerations, it will be seen that the numbers of animals present throughout the period does not alter to any

considerable extent; that carnivorous and saprophagous units constitute by far the greater part of the associations, and are present to about the same extent; and that phytophagous units are of relatively small number.

Comparison with Similar Communities in other Countries.

It is difficult to gain any definite evidence regarding the forest-floor populations of other countries. Shelford (3) gives some general descriptions of several such communities in temperate North America, but in rather a casual manner, and with scarcely any mention as to relative importance of the various groups. From what one can gather, however, the differences between the floor-fauna of these (deciduous) forests and of New Zealand ones must be considerable. Amphipods, the one species of which is perhaps the most characteristic animal of the latter, are absent; isopods receive comparatively little mention; molluscs (snails and slugs) are comparatively quite common; spiders are numerous, and certain centipedes and millipedes are mentioned, but seemingly insects are by far the most numerous inhabitants.

A more exact research has been made on the floor-fauna of pine-forests in Bavaria by Escherich and Pillai (6), an abstract only of which is available to the writer at present. The following summary is given:—

"The results of these patient investigations were collected in tables, and show that a great number of small organisms, some of them characteristic and others accidental, are to be found in the plant debris carpeting the soil of pine-woods. Among the first are nematodes, aptera, and acarians—these occur in enormous quantities, there being often many thousands per square metre; *Cecidomyia* larvae—several hundreds per square metre, and then in considerably fewer numbers (5–100 per square metre); Arachnida, Annelida, Chilopoda, Formicae, Diptera, &c."

The results are strikingly different from those obtained in the present investigations, but have been discussed in connection with Aptera above.

It must be remembered that the results given in connection with the present investigation apply to only seven months of the year, and that results obtained from a summer study of the same localities might be considerably different. This is to be anticipated, seeing that the ground would on the average be considerably drier and warmer.

Though scarcely comparable, some researches of Morris (7) on the fauna of arable land and of pasture at Rothamsted are of interest in this connection. On arable land it was found that half the fauna consisted of various insects; next most abundant were earthworms, Collembola, ants, millipedes, mites, and centipedes.

From a research on a forest-floor and on meadow-land near Washington, U.S.A., McAtee calculated that the number of animals per acre belonging to Arthropoda, Annelida, and Gasteropoda for forest was 1,216,880, and for meadow 13,654,710. A rough calculation of the numbers present in the two localities studied here shows that there are about 13,700,000 in the beech forest, and about 8,700,000 in the tawa forest. These are given for comparison, though, according to Buckle (8), "except where there is a pronounced infestation, the estimate of numbers per acre has purely a fictitious value." The writer is inclined to think, however, that though this may be the case when applied to single species, it is scarcely so when applied to an approximate computation of the whole fauna.

In conclusion, the writer would gratefully acknowledge assistance received from the following gentlemen who kindly aided him in the identification of

the animals concerned: Professor W. B. Benham, Mr. G. Archey, Mr. G. V. Hudson, Mr. T. Cockroft, Mr. J. G. Myers, Mr. W. R. B. Oliver, and especially Professor H. B. Kirk for his interest, suggestions, and criticism. To Mr. B. C. Aston the writer is indebted for naming the plants, and for general interest and criticism. Finally, he would record his indebtedness to his wife for her enthusiastic help throughout, especially in the laborious task of picking out and preserving the small animals.

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A New Genus and Eight New Species of Coleoptera.

By Albert E. Brookes.

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So far as I am aware, nothing has been attempted in the Dominion in the way of descriptive work on our Coleoptera since the death of the late Major T. Broun, in 1919. The removal of Broun's great collection to the British Museum leaves the Dominion without a large number of representatives of his more recently described species, thus greatly increasing the difficulty, in many instances, of absolute identification. Of the 4,323 species recorded by Broun in his *Manual*, *Ann. Mag. Nat. Hist.*, and *Bulletins*, 3,000 are represented in my collection, and in nearly every instance the identification has either been made or confirmed by Broun from the types in his collection. The systematic arrangement followed by Broun is now in a great measure obsolete according to later knowledge of the order. An up-to-date corrected catalogue of our Coleoptera and a revision of the *Manual* is very desirable, but would be a long and difficult task to undertake in New Zealand owing to the large amount of type material located so far away. Broun from time to time recorded many changes in the nomenclature, and generic location of species, but there is still much to be done in this respect. It is my intention when new species come under my notice to record them as far as possible, and to continue the numbering adopted throughout the *Manual* and the *Bulletins*.

SYSTEMATIC LIST OF THE NEW SPECIES.

Suborder ADEPHAGA.
Superfamily CARABOIDEA.
Family CARABIDAE.
Subfamily CARABINAE.
Genus *Mecodema.*
4324. *Mecodema exitiosus.*
4325. *Mecodema clarkei.*
Subfamily HARPALINAE.
Genus *Pterostichus.*
4326. *Pterostichus melanostolus.*

Suborder POLYPHAGA.
Superfamily BOSTRICHOIDEA.
Family PTINIDAE.
Genus *Ptinus.*
4327. *Ptinus maorianus.*
Group LAMELLICORNIA.
Superfamily SCARABAEOIDEA.
Family SCARABAEIDAE.
Subfamily MELOLONTHINAE.
Genera *Pyronota, Odontria.*
4328. *Pyronota inconstans.*
4329. *Odontria calvescens.*
Group PHYTOPHAGA.
Superfamily CERAMBYCOIDEA.
Family CERAMBYCIDAE.
Genus *Navomorpha.*
4330. *Navomorpha philpotti.*
Group RHYNCHOPHORA.
Superfamily CURCULIONOIDEA.
Family CURCULIONIDAE.
Subfamily OTIORHYNCHINAE.
Genus *Callomaoria.*
4331. *Callomaoria harrisi.*

The above classification is based on that followed by Leng in his recent "Catalogue of the Coleoptera of America North of Mexico," which is no doubt the most up-to-date list published to the present time, and is itself based on the painstaking researches of some of our most eminent coleopterists.

CARABIDAE.

MECODEMA Blanchard, 1853, *Voy. Pole Sud.*, p. 34.

4324. Mecodema exitiosus n. sp.

Elongate, flatly convex; head, thorax, and elytra nitid or subopaque, black; palpi, antennae, and tarsi piceo-rufous, terminal joints of antennae and palpi lighter. Head including eyes narrower than thorax and sculptured in front with several grooves of irregular shape, with one puncture on each side near base of mandibles, the sides longitudinally rugose, extending nearly to the base of eyes, the outer one forming an ocular carina, base nearly smooth, divided from the anterior portion by a well-marked transverse

line, above which the rugae extend across the head, but leaving dorsal area smooth; there is also an ocular setigerous puncture opposite the centre of each eye. Mandibles obliquely grooved at base, scrobes broad, eyes prominent; labrum rufescent, with six well-marked setigerous punctures. Thorax transverse, widest about middle, incurved at apex, anterior angles depressed and rounded, lateral margins slightly crenulate, very gradually rounded to behind middle, then abruptly narrowed to subrectangular posterior angles, central groove distinct, not reaching apex or base, crossed by numerous irregular wrinkled transverse striae, basal fossae obsolete, posterior rather small, triangular. Elytra elongate-oval, a little more than 2½ times length of thorax, widest opposite hind-thighs, gradually rounded to base, where it is wider than base of thorax; they are punctate-striate, interstices flatly convex, third, fourth, and fifth about equal width, the first only reaching apex, all others converging and forming a broken pattern there, seventh with four or five obvious punctures. Lower outer margin of anterior tibia slightly excavated. Antennae stout, last four joints pubescent, all except the two basal joints with apical punctures. Underside shining black. Prosternum smooth, broadly grooved between coxae, flanks punctate, with feeble rugose sculpture. Last abdominal segment finely transversely wrinkled, with two setigerous punctures on each side.

Holotype, male: Length, 27 mm.; breadth, 8·5 mm. In author's collection.

Allotype, female: Length, 22 mm.; breadth, 7·9 mm. In author's collection. Of a dull-black colour; thoracic sculpture less definite than in opposite sex.

Variety, male: Length, 23 mm.; breadth, 7 mm. In author's collection. Interstices of elytra broken up with close transverse impressions, giving the whole surface a crinkled appearance.

Material: A good series.

Locality.—Okauia, near Matamata, Waikato; collected at various times by the author.

This species does not seem to have any near allies; it is very destructive to wattle and cherry trees planted in bush clearings, owing to the larvae completely destroying the boles and roots, in which I found many of them living.

4325. Mecodema clarkei n. sp.

Elongate, flatly convex, nitid, black; antennae piceous; palpi, tarsi, tibia piceo-rufous. Head narrower than thorax, depressed in front, where surface is uneven, smooth behind, with two punctures between the moderately prominent eyes, forehead grooved in front. Labrum sinuously rounded, bearing five punctures. Mandibles grooved. Thorax broader than long, widest about middle, apex incurved, base subtruncate with short oblique angles, lateral side-channels shallow, with crenulated margins, median line distinct, not reaching apex or base; a slight frontal depression and two small indistinct submedian ones, posterior fossae moderately deep, with lateral margins slightly reflexed at angles, base narrowed. Elytra oblong-oval, gradually rounded, a little broader than thorax and twice as long. First, second, and third striae feebly impressed with rather distant small punctures, those on the seventh and eighth larger and well defined, extending to near apex, apical sculpture irregular, lateral margins irregularly

punctate. Antennae with last seven joints pubescent. Underside shining black. Prosternum smooth, flanks moderately distantly punctate. Metasternum with two conspicuous punctures, not a constant feature, as in some specimens they are wanting; abdominal segments faintly irregularly transversly striated, with a puncture on either side of middle, terminal segment with two punctures on each side close to margins.

Holotype: Length, 21 mm.; breadth, 7 mm. In author's collection.

Material: Five specimens, all females.

Locality.—Mount Constitution, Otago; elevation, 3,000 ft.

Named in honour of Mr. C. E. Clarke, Dunedin, who discovered this species on the 5th January, 1924.

PTEROSTICHUS Bonelli, 1809, *Obs. ent.*, vol. 1, tabl. synopt.

4326. Pterostichus melanostolus n. sp.

Body oblong, flatly convex, shining black; mandibles, palpi, tarsi, and four basal joints of antennae piceo-rufous; terminal joints of antennae and palpi lighter. Head not constricted behind eyes, with two elongate depressions extending from base of mandibles to just beyond frontal margin of eyes, and united by a distinct curved occipital line. Eyes moderately prominent. Labrum rather narrow, frontal portion incurved, with a puncture on each outer angle, and three median. Thorax one-sixth broader than long, with a well-impressed median line attaining base but not apex, anterior margin, marginate, basal fossae elongate, broad, extending to nearly half the length of thorax, situated midway between lateral margins and central line, slightly curved at base towards posterior angles, sides gradually rounded and narrowed to base, marginate with four setae on each side. Elytra oblong-oval, widest opposite hind-thighs, and from there slightly sinuated towards apices. Shoulders rounded, a little raised, discoidal striae not deep, feebly punctated, sides distinctly and moderately distantly punctate, third interstice tripunctate. Underside black, shining. Prosternum sulcate below, its episternum finely distinctly rugose, outer margins of metasternum and abdominal segments with similar sculpture, and each with one puncture on either side of centre.

Holotype: Length, 12 mm.; breadth, 4·3 mm. In author's collection.

Allotype: Length, 13 mm.; breadth, 4·8 mm. In author's collection. It has the ventral segment tripunctate on each side.

Material: Six specimens.

Locality.—Waitati, near Dunedin.

Another of Mr. C. E. Clarke's discoveries, who found it on the 13th October, 1923, and sent it to me under the name *Trichosternus sternalis*. Although closely allied to *P. sternalis* Broun (No. 1149), it is wider, the striae broader and deeper, and the antennae stouter. Another closely allied form is *P. mordax* Broun (No. 1688), which has the labrum truncate, while in the species now described it is incurved.

PTINIDAE.

PTINUS Linnaeus, 1767, *Syst. Nat.*, 1, 2, p. 565.

4327. Ptinus maorianus n. sp.

Body elongate, colour reddish-brown, dark above with yellowish-white markings. Head small, moderately coarsely sculptured with prominent

flattened granules which bear a single puncture. Antennae of the same colour as lower part of body, with last joint dark brown. Thorax about as long as broad, convex, with dilated sides and sculptured similar to head, disc raised, forepart descending, base constricted. There are several minute whitish dots forming a longitudinal line near lateral margins. Elytra wider than thorax, sides parallel to behind hind-thighs then obliquely rounded to suture; humeral angles oblique, raised; between these elevations and the suture there is another similar, with the intermediate spaces depressed; each elytron bears ten rows of elongately punctured striae. The derm is dark brown, and the whole surface closely clothed with intermixed cinnamon- and ash-coloured fine recumbent hairs. A narrow irregularly inwardly-curved fascia extends from just behind hind-thighs to suture; this does not quite reach lateral margins, being subcircular there and gradually tapering to and broadening out again to apices. Legs red-brown, femora and last tarsal joint only a little lighter in colour than elytra, tibia nearly straight. Underside: Prosternum without pubescence, transversely striate-punctate, with a conspicuous puncture on each side of centre. Metasternum remotely punctate. Fourth abdominal segment short, others of about equal length, clothed with fine silky recumbent pubescence.

Holotype, sex uncertain: Length, 2·8 mm.; breadth, 1·4 mm. In author's collection, with two paratypes.

Material: Four specimens.

Locality.—Belgrove, near Nelson. Discovered by the late Mr. T. Hall on the 24th October, 1914.

This interesting species is larger and more parallel-sided than *P. speciosus* Broun (No. 614); it more approaches *P. plagiatus* Broun (No. 3573) in form, but is narrower, the head distinctly so, and quite differently marked.

SCARABAEIDAE.

PYRONOTA Hope, 1837, Lacord., *Hist. des Ins. Coleop.*, tom. 3, p. 224.

4328. Pyronota inconstans n. sp.

Dark green, lateral margins bronze-green of varying shades; antennae (except club), tarsal claws, and legs rufo-piceous; underside blackish. Labrum truncate in front with slightly oblique sides, front angles shortly rounded, coarsely remotely punctate and strongly marginate. Clypeus more finely and closely punctate, incurved obliquely towards centre. Eyes not prominent. Thorax transverse, widest just behind middle, gradually narrowed towards front which is broader than head, bisinuate in front with rather prominent angles. Base strongly bisinuate, posterior angles subquadrate. A short and shallow basal depression, not reaching middle. Antennae with basal joint stout, second short, both of a reddish colour, club 3-articulate, the three outer leaves of about equal length, inner one shorter, all nearly black. Elytra at base not wider than thorax, broadest opposite hind-thighs, apices rounded, interstices of about equal width, striae feebly but distinctly punctate. Scutellum curvilinearly triangulate, brownish-red. Anterior tibia straight, bidentate, apical tooth longest and curved outwardly, upper one very small. Underside dark, not quite black, legs piceous; sternal process long, reaching to front of anterior coxae; surface more or less covered with pallid bristles, which also adorn the legs, bristles being stronger and erect in front, with fine and recumbent clothing on the abdominal segments.

Holotype, male: Length, 9 mm.; breadth, 4·5 mm. In Cawthron Institute collection.

Allotype, female: Length, 9 mm.; breadth, 4·8 mm. In author's collection. Pygidium in the female not covered by the elytra; the anterior tibia is tridentate, the upper tooth minute; all joints of antennae rufous, club black; articulations short, only one-fourth as long as those of male.

Paratypes: A male is also in author's collection, and a female in Cawthron Institute collection.

Material: Two of each sex.

Locality.—Aniseed Valley, Nelson. Collected by Mr. A. Philpott, of the Cawthron Institute.

Variety, male: Upper surface of a uniform crimson-lake colour, underside as in the typical form. The specimen has been returned with the type.

This species can readily be identified by its dark underside, by being larger and having a more robust form than any of the other described species.

ODONTRIA White, 1846, *Voy. Ereb. and Terr. Ins.*, p. 10.

4329. Odontria calvescens n. sp.

Head and clypeus red-brown, shining, thorax only a little darker; elytra fulvo-castaneous; antennae, palpi, and legs lighter. Head and clypeus remotely coarsely punctate, clypeus marginate, rounded in front, with sides a little more obliquely curved. Head a little narrower than thorax, sinuated in front and somewhat depressed, of about the same length in middle as clypeus. Thorax transverse, distinctly moderately closely punctate, anterior angles prominent, deflected and projecting, sides obliquely rounded to middle where it is widest, then subparallel to slightly-rounded posterior angles, base sinuate, convexly rounded both transversely and longitudinally. Elytra narrower than thorax at base, widest behind posterior thighs, base rounded, dorsally, evenly convexly rounded, striae distinct, and the whole surface punctate. Scutellum about as broad as long, its sides triangularly rounded, punctate. Elytral apices not covering pygidium, subquadrate, slightly rounded at extremities, first, second, and fourth interstices of about equal width, all others wider and subequal. Antennal club 4-articulate. The whole insect sparsely clothed with short yellow hairs, sides of head and thorax with longer stiff hairs. Legs fulvous, with tarsal joints, spines, and denticles of anterior tibia piceous. Colour of underside does not vary much from that of elytra. Abdominal segments shining, remotely punctate, those in centre being elongate, last segment narrow, and all sparsely clothed with short yellowish recumbent hairs.

Holotype, male: Length, 12 mm.; breadth, 6·4 mm. In author's collection.

Allotype, female: Length, 12 mm.; breadth, 6·5 mm. In author's collection. The inner articulation of antennal club is short, being only half length of adjoining one; in male it is about two-thirds as long.

Material: A single pair.

Locality.—Lake Ohia, Mongonui; taken at dusk off *Leptospermum* by the author on the 11th June, 1918.

This species does not appear to have any near allies, but can readily be identified by the rather bright colouring of the head and thorax, and the cordate, punctate scutellum.

CERAMBYCIDAE.

NAVOMORPHA Blanchard, 1853, Lacord., *Hist. des Ins. Coleop.*, tom. 9, p. 224.

4330. **Navomorpha philpotti** n. sp.

Uniformly red-brown, shining, tibia and upper part of femora lighter, lower third of femora and apices of tarsal joints blue-black, antennae normal. Head depressed in front, with oblique raised lateral margins which extend to eyes, two rather narrow furrows and a median one appear between antennae, the two outer filled with rather long and dense ash-coloured pubescence, curved outwardly and scarcely reaching base, discal portion between these lines smooth and shining, base slightly constricted, narrower than thorax. Also an elongated depression between frontal one and base. Thorax as broad as long, widest behind middle, sides sinuated, very gradually narrowed towards obliquely-rounded anterior angles, front truncate, base distinctly bisinuate, sides with swollen appearance, rugose, punctate, this sculpture extending beneath to sternum and reaching close up to lines bordering dorsal area, which is quite nude and shining, with two shallow depressions similar to head, one in front and the other behind the middle. Elytra wider than thorax, with rounded shoulders, very gradually narrowed towards apices, which are individually rounded; each elytron strongly broadly tricostate, the outer and inner coalescing, well behind posterior thighs and continuing on to apical angles, middle one shortened, allowing intervening furrows on either side to meet at extremity, furrows filled with pubescence of same colour as that in furrows of head and thorax. Suture and lateral margins finely marginated. Scutellum broadly triangular, with a medially depressed line, pubescent on lower half. Legs pubescent, femora and upper part of tibia sparsely clothed with pale hairs, lower part of tibia and tarsi more closely covered, underside of tarsi very densely clothed with short hairs. Underside: Head, sternum, and first four ventral segments of a blue-black colour, remainder same shade as above, and more or less clothed with pubescence of a silvery or ash colour.

Holotype, male: Length, 19 mm.; breadth, 4·3 mm. In Cawthron Institute collection.

Allotype, female: Length, 20 mm.; breadth, 5 mm. In author's collection. Rather lighter in colour than the male, antennae more slender, thorax with lateral margins straightly narrowed towards front, sides smooth, without any perceptible punctation, basal depression on head and the two similar ones on dorsal area of thorax wanting. Markings similar to male, but furrows between costae do not meet, being separated by a very narrow space, and distinctly divided at extremities.

Material: A single pair.

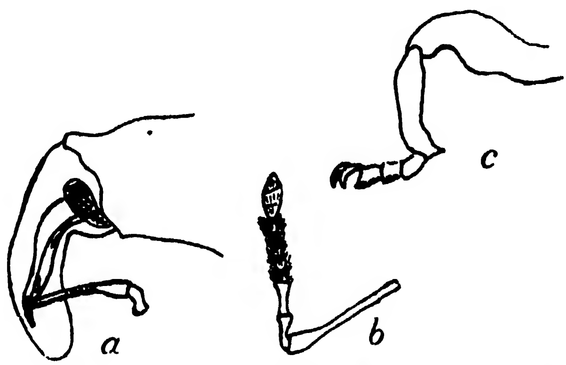
Locality.—Dun Mountain, Nelson. Discovered by Mr. A. Philpott, of the Cawthron Institute, on the 8th February, 1924, to whom I have much pleasure in dedicating this fine species.

The male of this species differs from all the other members of the genus in the strongly punctate thorax. The female in colouring is not unlike the female of *N. lineatum* Fabr. (No. 1028), but is larger, elytral furrows narrower and costae broader; but in form it more approaches *N. sticticum* Broun (No. 2261). This now makes the fourth recognized member of the genus so far brought to light. *N. neglectum* Broun (No. 1030), being synonymous with *N. sulcatum* Fabr. (No. 1029), will have to be eliminated from our lists.

CURCULIONIDAE; OTIORHYNCHINAE.

CALLOMAORIA n. gen.

Rostrum longer than thorax, half its width at base, not pterygiate, tricarinate, intervening grooves wide at base gradually narrowed towards apex, scrobes linear, beginning near apex and reaching eyes, open above. Head short, a little wider than rostrum, broadly convex below. Eyes depressed, moderately coarsely faceted, slightly obliquely transverse, widely separated, just free of thorax below. Scape inserted near apex, slender, thickened at its intersection with funiculus and attaining eyes. Funiculus 7-articulate, basal joint about two-thirds length of second, joints 3–6 of equal length, submoniliform, last joint obconical, club elongate-oval 3-articulate. Thorax subtruncate in front with well-developed ocular lobes, bisinuate behind, subquadrate. Scutellum invisible. Elytra oblong with prominent rounded shoulders, very little wider than base of thorax, sides rounded and narrowed, apices subvertically descending. Femora simple, moderately clavate in middle, with a subapical notch beneath, corbels rounded and cavernous. Tibiae flexuous, mucronate. Tarsi with



Callomaoria n. gen. *a*, rostrum, showing scrobe; *b*, antenna; *c*, anterior leg.

first three joints transverse, basal longer than second, penultimate expanded and deeply bilobed, densely finely setigerous beneath. Prosternum incurved in front, anterior coxae hardly contiguous, intermediate narrowly separated, posterior more distant. Mesosternum punctate in front, with a narrow process reaching to middle of intermediate coxae. Metasternum very short. Basal ventral segment only slightly longer than second, posterior margin sinuated, broadly hollowed between coxae: second nearly as long as preceding and quite as long as following segments combined, broadly strongly convex, third and fourth very narrow, depressed, truncate. Mentum moderate, not quite filling the buccal cavity. Palpi invisible.

Genotype: *Callomaoria harrisi* n. sp.

4331. Callomaoria harrisi n. sp.

Opaque, dark brown variegated with white, interspersed with coppery scales. Rostrum curved, tricarinate, the intervening grooves widest at base, narrowed in front. Scrobes, elongately-open above, apical area rugose, nude and shining, upper portion of rostrum clothed with coppery and grey coloured scales. Head short with an interocular depression, clothed

the same as rostrum. Antennae and tarsi dark reddish-brown. Scape and funiculus of about equal length, club finely pubescent, the funiculus ciliated. Thorax very little wider than head, obliquely narrowed towards front from the middle where it is widest, and from the middle subparallel towards the slightly bisinuated base, posterior angles roundly depressed. It is transversely raised at its widest part, which is somewhat broken up in middle, and distinctly depressed between this elevation and apex, which is also raised in centre, granulose in front, coarsely punctate behind, and sparsely clothed with small coppery scales. Elytra with base broadly V-shaped, a little wider than thorax, broadening to behind posterior thighs where it is widest, then considerably narrowed to apices. Humeral angles quadrate, sides immediately behind shoulders depressed, the whole surface above declivity sculptured with rather large punctures and small dark shining granules. In side depressions behind base is a small patch of cream-coloured scales, and in the same transverse line there are two smaller elevated spots, one each side of suture, immediately behind these one to two other small spots, and bordering top of declivity and continuing almost to elytral margins is a narrow line, all of the same pale colour. Declivity abruptly descending, practically without clothing, distinctly punctate, with four low rounded elevations on top, half-way down four others, and near apices two more, rather indistinct. Femora incrassate, flexuous, slightly rounded, notched. Tibia outwardly curved, a little flexuous, mucronate. Upper portion of femora clothed with dark-brown scales, also upper apical portion, middle banded with ash-colour. Tibia variegated with dark tawny, and bearing some curled hairs. Underside: Rostrum striate-punctate; head transversely finely striate; mesosternum and the first two basal ventral segments punctate; tarsi spongy beneath, densely clothed with pallid silky pubescenc..

Holotype, female (by selection): Length, 8 mm., including rostrum; breadth, 3·5 mm. In author's collection.

Allotype, male (by selection): Length, 5 mm., including rostrum; breadth, 2·4 mm. In author's collection. This does not differ materially from the other sex except in its smaller size. The head is clothed with almost white scales in which there are two minute dark-brown dots.

Material: Several specimens of each sex.

Locality.—Ohakune, Main Trunk line. Discovered by Mr. T. R. Harris, in whose honour I have much pleasure in naming it, and to whom a set of paratypes are returned.

The abdominal structure of this weevil is peculiar, and, having no known near allies, makes it difficult to find a satisfactory position for it. For the present it may be placed near *Agatholobus*, but the two genera are widely different.

Biological Notes on New Zealand Heteroptera.

By J. G. MYERS.

[*Read before the Wellington Philosophical Society, 24th October, 1923; received by Editor, 29th July, 1924; issued separately, 26th April, 1926.*]

Plates 81–86.

CONTENTS.

1. INTRODUCTION.

THE order Hemiptera in the widest sense includes all those insects which bear sucking mouth-parts and undergo a gradual metamorphosis. Several writers have pointed out that no order of insects has been more neglected by entomologists or is more directly connected with the welfare of the human race than the Hemiptera. (Britton, 1923, p. 10.) Probably the most neglected forms of the whole order are included in the suborder Heteroptera, distinguished, except in a few aberrant species, by the division of the forewings, or *hemielytra*,* into a basal thickened portion (made up of *corium* and *clavus*) and an apical membranous part. The Heteroptera, so far as the palaeontological evidence goes at present, are the younger of the two suborders. Morphologically the Homoptera show the greatest diversity, but ecologically the Heteroptera are the most varied. Thus the former include only plant-feeding forms,† the latter both vegetarian and carnivorous species; the Homoptera are all free-living, while the Heteroptera include obligate ectoparasites; the Homoptera are all terrestrial,‡

* Hart (1919) and Saunders (1892) call the same organs "elytra," the former writer using this as "a convenient term for thickened opaque forewings generally." But as only part of the wing is thickened and opaque it is surely more logical to use the term "hemielytra" in this case. Kirkaldy termed the forewings of both Heteroptera and Homoptera "tegmina," but it seems more convenient to reserve this appellation for the uniform-textured, usually more or less coriaceous forewings of Homoptera and Orthopteroid orders.

† Kirkaldy (1909, p. 51, note 7) mentions an isolated instance of a Fulgoroid sucking blood from a man's bare foot. Lawson (1920, pp. 20–21) mentions instances in the Cicadellidae.

‡ Certain Aphididae live on water-lilies and may be occasionally submerged.

but the Heteroptera range from the driest stations to the surface of the open ocean itself, in this last case exhibiting a completer independence of land than any other members of the class Insecta.

The study of the biology of Heteroptera, or *bugs* proper, has received a great impetus in recent years by the publication, firstly, of E. A. Butler's monumental work on the bionomics of the British species, embodying the labours of a lifetime; and, secondly, of such intensive studies as Hungerford's *Biology and Ecology of Aquatic and Semi-aquatic Hemiptera* (1919) and Hart's *Pentatomoidea of Illinois* (1919). Reuter's classical *Charakteristik und Entwickelungsgeschichte der Hemipteren Fauna der Palaearktischen Coniferen* (1909) remains a model for ecological work on the Hemiptera.

The present paper, the preparation of which has been assisted by a New Zealand Institute research grant of £10, contains complete data for not a single species. Nevertheless, it brings together all that is at present known of the biology of the Heteroptera occurring in this country. In view of the writer's departure from New Zealand at an early date, it was deemed advisable to gather up all material so far collected and place it on record as a basis for future work. In order that the technical descriptions may be kept as brief as is consistent with accuracy, most of the essential features in pre-adult structure have been expressed as much as possible by illustrations, leaving chiefly the important matter of colours and colour-patterns for treatment in the text.

Dr. E. Bergroth, the highest living authority on the Heteroptera, has now been working for some years on the New Zealand species. The present paper therefore deals solely with life-history, distribution, seasonal occurrence, host plants, and habits—in short, with such studies as must necessarily be made by a person on the spot—leaving the whole of the systematic work in far more capable hands.

Owing to the fact that frequent travelling while most of the actual rearing of bugs was in progress subjected the insects to most unnatural changes of climate, and sometimes of food, little importance can be attached to the periods taken for the different stages of development. In several cases it was only constant attention by my wife which ensured any results at all.

To many New Zealand entomologists and others who have collected Heteroptera for the writer hearty thanks are due. In most cases their names are mentioned under the names of the species concerned.

For assistance of every kind generously offered I am deeply indebted to the following overseas hemipterists: Drs. E. Bergroth, H. M. Parshley, H. B. Hungerford, J. R. Malloch, and Dayton Stoner, and Messrs. F. Muir, A. E. Butler, and W. Downes. Mr. Butler kindly gave me the fullest information from his lifelong experience of rearing these insects.

Mr. E. H. Atkinson, besides collecting material himself, gave me every assistance in the botanical side of the study. Nearly all plant-identifications were made or confirmed by him.

The writer is very grateful to Mr. E. B. Levy and to Mr. Harvey Drake for the photographs which are respectively credited to them.

2. THE NEW ZEALAND HETEROPTERA FAUNA.

Bergroth (*in litt.*) recognizes forty-four families of the Heteroptera of the world. Of these, nineteen are represented in New Zealand. The order in which the New Zealand families are discussed exactly follows the grouping of the above writer. So far as number of species is concerned, no census

can be taken until his work on the material already in hand is finished. The writer has based the following survey on the results of his own collecting and of such other workers as have sent him material.

The three families, Miridae, Lygaeidae, and Aradidae, together probably possess more species than all the sixteen other families combined. The Miridae are strongest also in number of individuals, with the Lygaeidae and the Aradidae almost certainly coming next in this order; but such a matter is rather difficult to estimate.

The next most numerous family (in species), the Pentatomidae, has only eight species, while the Anthocoridae, Saldidae (Acanthiidae), Reduviidae, Nabidae, Cydnidae, Henicocephalidae, Notonectidae, Veliidae, and Corixidae follow in that order with fewer than eight. The remaining families—Peloridiidae, Cimicidae (introduced), Gerridae, Tingidae, Neididae, and Pyrrhocoridae (introduced)—are represented in collections each by one species only. While future collecting will indubitably add greatly to the number of species, it is unlikely to change materially the relative strength of the various families as estimated above. The conspicuous Pentatomidae will probably not be added to very much, so that this family may be placed even lower on the list.

The Miridae are very much neglected by collectors, and the representation of this family will certainly be enormously increased, while the Lygaeidae and the Aradidae are particularly abundant in those cryptozoic habitats which the forest conditions of New Zealand foster so preeminently, and which without a doubt still shelter numbers of undiscovered forms. Field-work in the future will therefore probably show these three families to dominate the Maorian Heteroptera fauna to an extent even greater than is at present suspected. Since the Miridae are the most abundant Heteroptera in any fauna, forming, for instance, almost one-third of the total Heteropterous fauna of the palaearctic region (estimated from Oshanin's *List*, 1912), their dominance in New Zealand demands no special explanation. The Lygaeidae are also usually rich in species, forming, for example, about one-seventh of the British Heteroptera; but the New Zealand percentage is higher, being approximately one-fifth. The Aradidae, however, form no more than one-eightieth of the British Heteroptera fauna, while in New Zealand they will include nearly one-tenth of the total Heteroptera. New Zealand was originally and above all a land of forests—the North Island, with the exception of the narrow Aupori Peninsula in the extreme north, being once almost wholly wooded, while in the South Island the bush covered only a slightly smaller proportion of the total area. Beneath the bark of such countless trees a rich fauna of Aradidae was to be expected; and, further, the accumulated leaf-mould of the forest-floor gave refuge to a teeming population of both Aradids and Lygaeids.

Among the other peculiarities of the fauna are the complete absence of the almost cosmopolitan Nepidae and Coreidae,* the lack of the widely spread families Gelastocoridae, Hydrometridae, Mesoveliidae, Hebridae, Naucoridae, and Belostomatidae, and the very scanty representation of aquatic and semi-aquatic bugs generally. Of these last only the Corixidae, Notonectidae, Gerridae, and Veliidae occur at all, and these make up only

* A new species of the Coreid genus *Leptocoris* (*Serinetha*) has been found at Taihape by Mr. W. G. Howes. It is possibly endemic, but Dr. Bergroth thinks it more probable that it has been accidentally imported from some other Pacific island or from Australia.

about half a dozen species among them. The Corixidae, which form one-sixteenth of the British Heteroptera fauna, make up here only about one-hundredth. This scarcity of water-bugs in a country so well watered as New Zealand, abounding as it does in lakes, rivers, and streams, is very remarkable. The streams are, however, generally swift and rock-bottomed, and the lakes clear and cold. Blepharoceridae, Simuliidae, Plectoptera, Perlaria, and other groups which in their aquatic instars prefer swiftly-flowing water, are abundant, at least in individuals. But Culicidae and Dytiscidae are poorly represented, like aquatic Heteroptera, in number of species. It seems probable, therefore, that conditions favourable both to surface-film insects (*e.g.*, Gerridae, Veliidae) and free-swimming insects are lacking in New Zealand. The absence of the bottom-dwelling Nepidae is harder to explain, but it is certainly a fact that stretches of suitable more or less stagnant water are not common features of the usually hilly New Zealand landscape. The Saldidae, since they are not entirely dependent on water, have not been included in the discussion on water-bugs, but the fact that they are well represented, at least in individuals, is in keeping with the general abundance of torrent insects, because Saldids are addicted to running on the rocks and stones bordering even the swiftest streams.

After the extremely rich and varied Pentatomid fauna of Australia, where these bugs form the most abundant family of described Hemiptera, with nearly four hundred species, the scanty representation of this family in New Zealand is surprising. Nor is the infinitesimal number of endemic forms—only four—likely to be materially increased, since Pentatomids are the most often collected of Heteroptera. The New Zealand species are among the most obscure of the family, although a remarkable dull-black brachypterous form, discovered a few years ago by Miss Stella Hudson, and now being described by Dr. Bergroth, is of the highest taxonomic interest.

3. DEVELOPMENT AND METAMORPHOSIS.

Comstock (1920) has given his support to a scheme which distinguishes between insects with a metamorphosis (Metabola) and insects without (Ametabola). In the former he recognizes three main types—viz., complete, or *holometabolous;* incomplete, or *hemimetabolous;* and gradual, or *paurometabolous.* All Hemiptera in their passage from egg to adult undergo a gradual metamorphosis, the young hatching in a form fairly similar to that of the parent, furnished with mouth-parts and legs of the same kind as the adult, but devoid of wings until maturity. The wings develop in external pads in the typical exopterygote manner. The transformations of certain sternorrhynchous Homoptera approach somewhat near to true holometabolic development.

The student of the Lepidopterous insects or other Holometabola usually feels well on the way to a complete life-history when he has discovered and described the larva and pupa of the insect under consideration. But the larva may be any one of several instars from egg to pupa, each instar corresponding to one of the definite stage-forms of an Hemipterous insect, although seldom presenting the diversity which characterizes the latter. In view of this diversity, the student of the Paurometabola usually requires to know every one of the five well-marked stadia from egg to adult.

This brings up the question of a name for the pre-adult instars in Paurometabola. Kirkaldy (1907B, p. 136) strenuously maintained that the

terms "larval" and "pupal" have no place rightly in the horismology of the Homomorpha. He therefore called all instars between egg and adult (usually five in Heteroptera) by the term "nymph," in which usage he has been followed by a large and increasing number of hemipterists, especially American workers. Thus Comstock (1920) very neatly restricts the titles "larva" and "pupa" to the Holometabola, and for the instars between egg and adult in Hemimetabola and Paurometabola uses the names "naiad" and "nymph" respectively.

Some British and Continental workers largely apply the term "larva" to pre-adult instars in Heteroptera, sometimes calling the last one a "nymph." This latter usage corresponds with the practice of ixodologists, who almost unanimously speak of the first instar in the Ixodidae as a "larva" and the second as a "nymph." Also, as Comstock (1920, p. 176) writes, "In old entomological works, and especially in those written in the early part of the last century, the term 'nymph' was used as a synonym of pupa."

The term "larva" is, of course, a general one in zoology, and the use of special terms like "nymph," "naiad," and "pupa," to say nothing of "nauplius" and "zoea," and a host of others which have been found necessary in the study of animal ontogeny, unfortunately tends to obscure the essential homology which would be expressed were the term "larva" and no other used for all pre-adult stages. But the needs of comparative study demand a specialized nomenclature, and the terms "larva" and "pupa," "naiad," "nymph," indicating as they do so neatly the three main types of insectan metamorphosis, seem to the writer to meet these needs. It is perhaps unfortunate that to the most specialized type (holometabolous) the most generalized name (larva) should be given, while the less specialized types which lead up to this in evolutionary series receive more specialized titles; but the students of holometabolous metamorphosis are so greatly in the majority, and have so long used the term "larva" in an entirely specialized sense for their caterpillars, grubs, and maggots, that this usage must be considered as irrevocably set—a usage as deplorable as that which borrowed terms from vertebrate anatomy for the wholly non-homologous segments of the insect-leg.

In this paper I use the term "nymph" for all instars between ovum and imago, thus emphasizing the gradual change through which they pass, and avoiding any confusion with the specialized terms of holometabolous development, among which titles that of "larva," in the strictly entomological sense, must certainly be included.

In all Heteroptera known to me there are five nymphal instars. This appears to be general throughout the suborder. In 1921 (p. 237) I wrote that "Although Osborn considers five instars to be the normal number in the Hemiptera, Kershaw and Kirkaldy note eight in the case of *Dindymus sanguineus* Fabr., an Oriental Pyrrhocorid; and there is every indication that *Ctenoneurus hochstetteri* passes through an equally large number of stadia." Kershaw and Kirkaldy, in the same paper, however, state that "such a large number of moults in a Heteropteron is unprecedented, and requires wider investigation" (1908, p. 597). They mention the only other case of more than five instars in the Heteroptera—that of the Ethiopian Pentatomid, *Bathycoelia thalassina*, which Schouteden reports to have seven nymphal instars. Bergroth, however, has found more than five in some Nabidae. The whole tendency of modern research on the Heteroptera goes to show that five is the number of stadia in the great majority of species. This is certainly true of all New Zealand bugs

investigated fully enough, with the doubtfully possible exception of *Ctenoneurus* quoted above, which was not bred uninterruptedly from egg to imago. Without such direct rearing there is the possibility that changes in colour and size between moults were mistaken for true metamorphosis.

It is usual, at least in the Pentatomidae, for the first instar to take no nourishment, but to remain clustered, often near the empty egg-shells.

4. BRACHYPTERY AND PTERYGO-POLYMORPHISM.

A reduction in the organs of flight is a well-known phenomenon in the Hemiptera. In some cases the abbreviation characterizes all the members of a species; at other times both brachypterous and macropterous forms occur within the limits of a single species—this condition being known as "pterygo-polymorphism."

Detailed studies in this connection have been made on the European fauna by Flor, Sahlberg, Reuter, and Butler. Too little is yet known of the New Zealand Heteroptera, and too few series have been collected, to analyse completely the incidence of these phenomena here. A few notes may, however, be of interest.

Brachyptery occurs in New Zealand in the following families: Miridae, Cimicidae (introduced), Nabidae, Reduviidae, Lygaeidae, Neididae, and Pentatomidae. The completely apterous condition is attained by certain members of the Gerridae, Veliidae, Reduviidae, and Aradidae. The Corixid *Diaprepocoris zealandiae* usually lacks hindwings, according to Hale. Thus out of the eighteen established families of the Maorian region no fewer than eleven, or 61 per cent., possess some species exhibiting reduction in flight-organs. The corresponding percentage for the British fauna is still higher, being 64.

Of the families in which reduction of alary organs is least frequent the Pentatomids are the most noteworthy. Yet the hitherto undescribed New Zealand species in which brachyptery occurs appears to be represented only by short-winged individuals. Of this interesting alpine Pentatomid, however, only two specimens have so far been collected, and very little is known of its habits.

Reuter (quoted by Kirkaldy, 1906, p. 283) mentions that species with forms more or less brachypterous usually live on herbage or on the ground itself, and are never found on trees or bushes. Kirkaldy (*op. cit.*, p. 284) disputes this so far as the Homoptera are concerned, by stating that "in the tropics there are certainly many dimorphic leaf-hoppers arboreal." Reuter's observations were, however, made largely on the Heteroptera, and in this suborder observations on the New Zealand fauna, as indicated by the above review, strongly support his conclusion.

For speculation as to the cause and function of pterygo-polymorphism the reader is referred to Butler (1923, p. 8) and Kirkaldy (1906, pp. 282–84). The writer has no new data or fresh theory to contribute to this aspect of the matter.

5. DISTRIBUTION.

In this section the discussion is forced to neglect a large proportion of the undescribed forms, including nearly all the Miridae. For this and for other reasons, therefore, the effect of future work in the following statistics will probably be to add more and more to the endemic element.

This section, then, is very incomplete, in that it deals with only forty-eight species; but collecting by the writer and his friends has been

sufficiently widespread in both Islands to give a fairly reliable indication of the distribution of these forms, at least as far as the mainland is concerned. The outlying islands remain, of course, almost a *terra incognita* to the hemipterist, the Kermadecs and the Chathams being the only ones from which Hemiptera have been recorded. From Stewart Island, even, apparently only one species of Hemiptera has been collected.

Of the forty-eight species discussed, five are practically cosmopolitan, seven occur also in Australia, one in Australia and Ceylon as well as New Zealand, three are found also in other Pacific islands, and, finally, thirty-two appear to be endemic, including one species closely related to an Australian form.

The Peloridiid, related to the Magellan genus *Peloridium,* and the Ploiariine, *Ploiaria huttoni,* found in New Zealand and Juan Fernandez, are, as suggested by Bergroth, evidences of South American affinities. A full elucidation of the relationships of New Zealand Heteroptera must await the completion of Dr. Bergroth's work. In a local worker like the present writer the necessarily wide knowledge of outside faunas is lacking.

The cosmopolitan species include two predaceous bugs, two forms which accompany man in his dwellings and sheds, and one which is attached essentially to introduced plants.

The Australian element consists of a species attached to introduced plants, two predaceous species, three with no very restricted feeding-habits, and one (*Arocatus rusticus*) occurring on *Parsonsia heterophylla,* an endemic plant belonging, however, to a genus which has representatives in Australia.

The other non-endemic species include one pelagic form, one carnivorous, and two wide-ranging species with non-restricted feeding-habits.

Taking the foreign element altogether, probably four species have been introduced by the agency of the white man, these being *Cimex lectularius, Lyctocoris campestris, Stenotus binotatus,* and *Eurystylus australis.* At least one other introduced Mirid—a species of *Calocoris*—occurs commonly on grasses. *Cimex lectularius* was quite unknown to the Maori people before the advent of Europeans (see Myers, 1922, pp. 7–8).

Turning now to the endemic species, we find that three occur in both North and South Islands and in the Chathams, sixteen are found in both North and South Islands, ten are confined to the North Island, and three, apparently, to the South Island. There is thus a strong indication that the North is the richer in Heteroptera. The Australian species in the fauna tend to be commonest in the north of the North Island, and to decrease in abundance southwards, being sometimes altogether absent from the South Island, or frequently reaching no farther south than the Nelson district, lat. 41°, which is as far north as the southern portion of the North Island. This is even more clearly exemplified by several species of introduced Australian Homoptera, which occur in phenomenal numbers in the North Island, but are rare or absent in its southern portion south of 39°, and in the case of one species are found commonly in Nelson (lat. 41°). The extension of a considerable number of North Island species to the northern part of the South Island is paralleled by a similar distribution in the case of the plants. Thus Cockayne (1907, p. 313) states: "Strange as it may seem, Cook Strait forms no line of demarcation between the North Island and the South Island floras—so far, at any rate, as the lowland region is concerned. It is not until latitude 42° south is reached that the South Island vegetation properly commences. . . ."

6. GENERAL ECOLOGY.

In considering the ecology of the Heteroptera no distinction will be made between indigenous and introduced species so long as the latter are established. The following scheme takes account of all species known to me, whether described or not, provided sufficient data are available to gauge their ecological position. The most important factor in the distribution of the Heteroptera seems to be their relation to plants. This relation tends to be expressed rather in terms of flora than of vegetation: in other words, a bug is restricted to a group (whether order, family, or genus) of allied plants rather than to the plants of any given association or formation. For instance, a single species of Mirid of a pale-green colour marked with vivid red is attached both to the tree-fern *Cyathea dealbata* in the forest and to bracken-fern (*Pteridium esculentum*) in the open. *Rhopalimorpha obscura* affects grasses and sedges usually in clear country, but it also occurs on the latter when these plants fringe the course of a forest-stream. A species of *Nysius* occurring almost solely on *Raoulia tenuicaulis*, and abounding at elevations up to 4,000 ft., follows this plant in river-beds down to sea-level; but here we have a somewhat different case, since the new habitat obviously offers more points of ecological similarity than in the case of the fern-loving Mirid and of *Rhopalimorpha* cited above.*

The following categories will be found to exhibit surprisingly little overlapping. The habitats described are, as far as can be ascertained, those in which the species in question spend the greater part of their lives. Seasonal changes in population due to differences between hibernation shelter and summer haunts are indicated in the detailed notes accompanying the main scheme.

(1.) *Species confined to Buildings and their Vicinity.*—Here belong *Cimex lectularius* (Cimicidae) and *Lyctocoris campestris* (Anthocoridae), both, be it noted, practically cosmopolitan, and both more or less parasitic. The apterous Ploiariine, *Ploiaria huttoni*, occurs in sheds. This is a carnivorous species.

(2.) *Widely-ranging Carnivorous Species.*—The two Pentatomids *Cermatulus nasalis* and *Oechalia consocialis* may be included here. The other predaceous bugs, such as the Reduviidae and Gerridae, are all specialized to a certain extent in habitat.

(3.) *Species occurring on Trees, Shrubs, and Lianes.*—When the vast extent of originally forested country in New Zealand is considered, it is no matter for surprise to find that more than half the Heteroptera must be included here. A good case could be made out for treating this section as forest species, and bringing in also the forms confined to the leaf-mould which is so characteristic a feature of the forest-floor. Thus would be obtained an unbroken sequence from the upper layers of forest foliage to the leaf-mould stratum itself, the latter being ecologically much more similar to the cortical and subcortical habitat than to any of the terrestrial stations of open country. Such treatment is, however, rendered impracticable—firstly, by the occurrence of numerous phytophagous species on woody plants entirely outside the forest (*e.g.*, Miridae attached to *Leptospermum* and *Cassinia*); and, secondly, as mentioned above, by the restriction of various other phytophagous species to botanical families rather

* Evidence will be adduced in a forthcoming paper on New Zealand auchenorrdynchous Homoptera showing, apparently, that these insects are restricted almost as much to plant associations as to botanical families.

than to plant associations. The essentially tropical character of the New Zealand rain forest has here its important effects. The Heteroptera of the forest change their quarters very little throughout the year, and then usually only from one part to the other of the same tree or its vicinity; the trees, with two or three exceptions, are all evergreen, and offer as much shelter in winter as in summer. This is in striking contrast to palaearctic conditions, under which Reuter found a large and varied assemblage of bugs seeking winter quarters on the conifers, which are there practically the only evergreen trees.

The species affecting woody plants and leaves fall readily into the following three minor groups:—

(*a.*) Those living among live foliage and twigs. Here is included considerably more than half the Miridae; the Lygaeids *Targarema stali*, *Arocatus rusticus*, *Nysius clavicornis*, and *Nysius* sp. 1; and the Pentatomids *Oncacontias vittatus* and *Zangis amyoti*.

(*b.*) Species occurring among masses of dead vegetation and epiphytes such as mosses and lichens. These are pre-eminently sylvan species. The dense masses of dead fronds (Plate 81, fig. 1) hanging from the heads of such tree-ferns as *Cyathea medullaris*, and the thick growth of Hymenophyllaceae, Polypodiaceae, mosses, and lichens covering the trunks of trees and logs, afford shelter to the insects of this category. Typical families are Anthocoridae and Reduviidae (Ploiariinae only).

(c.) Species living beneath bark of living or dead trees. The bark of such trees as *Dacrydium cupressinum* and *Podocarpus dacrydioides* flakes off, while that of *Leptospermum*, *Fuchsia excorticata*, *Podocarpus totara*, *Dracophyllum Traversii* is shed in long, fibrous strips, of which several layers may be detached at once. In these situations a considerable number of bugs may be found; but the typical bark-dwelling species, the Aradidae, occur more plentifully beneath the loosened bark of dead trees, thus incidentally proving that the sap of live trees cannot be their main food. Some species of the Aradidae, as mentioned later, occur, particularly in their nymphal stadia, in the forest-floor. The abundance of Aradidae in New Zealand has been already emphasized. The other bark-dwelling Heteroptera include one undescribed Henicocephalid, found with its immature stages in the same situation; an undescribed Ploiariine Reduviid; and a few Anthocorids, the flattened form of which cannot be an adaption to subcortical existence, since it is equally developed in species common elsewhere. Outside Heteroptera may occasionally seek subcortical shelter for hibernation.

(4.) *Species occurring on or near the Ground.*—These species are more considerably augmented than those of any other section by a distinct winter population of hibernating forms, especially in open country. Four minor groups may be distinguished,—

(*a.*) Those of low herbage generally (open country). Most of the Nabidae and the Lygaeids, *Nysius huttoni*, *Nysius* spp. 2 and 3, and *Taphropeltus putoni* must be placed here. Probably our only Neidid should also be included.

(*b.*) Species frequenting grasses, sedges, and rushes (Plate 81, fig. 2) (of forest or open country, or both).—A very large number of species is attached to these plants. Among them are most of the remaining Miridae; the only recorded Tingid; the Lygaeids *Cymodema* n. sp., *Orthoea nigriceps*, and *Margareta dominica*; and the Pentatomids *Dictyotus caenosus* and *Rhopalimorpha obscura*.

(*c.*) Burrowing forms. These occur in open country only, and include the Cydnids *Hahnia australis* and *Chaerocydnus nigrosignatus*, both more or less attached to the sea-coast. The other Cydnid, *Pangaeus scotti*,* almost certainly will be placed here when its biology is known.

(*d.*) Species inhabiting the leaf-mould of the forest-floor. From a strictly ecological point of view these should follow immediately on the groups 3 (*b*) and 3 (*c*), to which they are closely related. The majority of them, both in species and in individuals, are Aradids and Lygaeids, especially nymphal instars. The chief species of the latter family belong to the genus *Metagerra*. Plentiful also, in certain localities, is a species of *Henicocephalus*, both as nymph and adult. The latter is also, of course, at times a thoroughly aerial insect, its habit of dancing in the air in companies being well known. The leaf-mould is swarming with mites and with the immature stages of numerous other Arthropods, on both of which *Henicocephalus* possibly preys. Finally, in this habitat occurs the Peloridiid *Xenophyes*, both as adult and nymph. In passing, it may be noted that several Homoptera spend their earlier stages in the leaf-mould, and one at least (a new genus of Ulopidae) passes there its whole life-cycle.

(5.) *Water-frequenting Species.*—The anomalies of the New Zealand water-insect fauna have already been mentioned in the introduction. Only five families of aquatic and semi-aquatic Heteroptera occur, and these achieve only the barest representation. They may be grouped in two minor categories :—

(*a.*) Semi-aquatic forms. The Acanthiidae are numerous in certain localities in individuals, but the number of species is apparently small. While occasionally they venture on to the surface film itself, their chief haunts are the rocks and mud of the shore. The margins of rocky torrents, of rivers, ponds, and lagoons, of the clear lakes, and of the sea itself, yield specimens of these insects.

(*b.*) Aquatic forms. Here belong the two Corixids and the two Notonectids, both families living most of their time below the surface ; and the two Veliids (*Microvelia* spp.), and the Gerrid *Halobates sericeus*, all three insects of the surface film, the latter species living on the face of the ocean itself.

The relations of Heteroptera to plants from a floristic point of view have been dealt with under European conditions by Butler (1923) and Reuter (1909). The New Zealand data, though necessarily much more scanty than that collected by the above writers, afford some interesting comparisons. Thus the Orchidaceae, altogether avoided by the British Heteroptera, are similarly shunned in New Zealand, in spite of the fact that the species of indigenous orchids are almost twice as numerous as in Britain. Butler (1923, p. 10) gives a list of other plant-families which are entirely avoided in Britain. Among these the Linaceae and Apocynaceae both contain plants attractive to Heteroptera in this country, *Linum* sp. yielding *Nysius huttoni*, and *Parsonsia heterophylla* (Apocyn.) acting apparently as sole food-plant to *Arocatus rusticus*. Butler finds the Ranunculaceae, Cruciferae, and Caryophyllaceae with few adherents ; in New Zealand these three families are entirely neglected. The Leguminosae are fairly popular, although less so than in England ; but the very widespread and abundant introduced *Ulex* and *Sarothamnus*, which are among "the special favourites" in their native land, have so far yielded no Heteroptera in New Zealand.

* I am entirely unacquainted with this species.

Yet the similarly introduced *Medicago* and *Trifolium* support a considerable number. The Rosaceae, with the Malaceae, are attractive in both countries; but again there is a curious anomaly, in that *Crataegus*, " the chief favourite " in England, seems here to have no Heteroptera attached to it, although it has been planted extensively in every part of the country. The Umbelliferae are much less frequented in New Zealand than in Britain. The Onagraceae show no cases of definite food-plants in this country.

The Composites are the second most favoured family in New Zealand, and are popular also in Britain. Butler remarks that " the Rubiacaee are particularly associated with certain Capsids, " a fact specially interesting in view of the abundance of these bugs in New Zealand on several indigenous plants of the Rubiaceous genus *Coprosma*. The Scrophulariaceae are little attractive in either country. *Veronica*, the chief New Zealand genus, is noted for its astringent properties. The Ulmaceae (introduced in New Zealand) and the Urticaceae yield relatively fewer species than in England, *Elatostema* in the latter family being singularly barren of insects generally. The Fagaceae are very popular among the Heteroptera of both faunas. The Gramineae support by far the largest number of species in New Zealand, and are strongly favoured in England also. The Juncaceae, very attractive in both countries, are especially used as hibernating-quarters in New Zealand.

Perhaps the greatest contrast occurs in the case of the Pinaceae. In Europe these " are very productive . . . not only are they the food-plants of many species, but also, as evergreens, they often furnish a winter residence to such species as survive that season in the adult form, since they afford much better protection from the weather than the then leafless deciduous trees. Reuter (19) has recorded 190 species of palaearctic Heteroptera as having occurred on coniferous trees . . These he classifies into three groups according as (i) they depend upon deciduous trees or low plants for their food and resort to the conifers only for hibernation, or (ii) are found on both conifers and deciduous trees or low plants even in summer-time, or (iii) occur exclusively on coniferous trees." In New Zealand the Coniferae are represented chiefly by Taxaceae, which are plentiful and widespread, but from which I can find only four records of Heteroptera, two of which were probably cases of hibernation, while from the two indigenous Pinaceae (*Agathis* and *Libocedrus*), and from the numerous and extensively planted imported pines, none of these insects have been taken. As most of the indigenous broad-leaved trees are non-deciduous, the conifers are not necessary as hibernating shelters, while as food-plants the evidence seems to indicate that the Taxaceae in New Zealand are very much less attractive than the Pinaceae in Europe.

The ferns, as might be expected by their abundance in New Zealand, are considerably more favoured than in England, although as food-plants probably not proportionately so. As shelter they attract a number of carnivorous forms.

Among popular New Zealand plant-families which have no representatives in Britain may be mentioned Myrtaceae, Pittosporaceae, Cunoniaceae, Epacridaceae, and Myoporaceae.

The most noteworthy cases of definitely restricted association include those of a Mirid with *Pteridium* and *Cyathea*, of *Megaloceroea* and *Rhopalimorpha* with *Glumiflorae*, of *Stenotus binotatus* with Gramineae, of *Margareta dominica* with *Gahnia*, of *Romna* sp. with *Leptospermum*, of *Arocatus rusticus* with *Parsonsia*, of certain Mirids with *Myoporum* and with certain *Coprosmas*

respectively, of *Nysius* sp. 1 with *Cassinia leptophylla*, of *Nysius* sp. 2 with *Raoulia tenuicaulis*, and of a Mirid with *Senecio elaeagnifolius*.

To sum up, the most attractive orders in New Zealand, arranged in descending order, are the Glumiflorae, Rosales, Campanulatae and Myrtiflorae (equal), Filicales, Rubiales, Fagales, Polygonales, Liliiflorae. The most favoured families are Gramineae (many introduced plants), Compositae, Juncaceae (especially for hibernation) and Myrtaceae (equal), Rubiaceae, Fagaceae, Polygonaceae, Cyperaceae, Cyatheaceae, Rosaceae, Malaceae (introduced), Leguminosae (chiefly introduced plants), Onagraceae.

Among large New Zealand plant-families from which no Heteroptera have been recorded may be mentioned the following (arranged in descending order, and compiled from Cockayne, 1921, pp. 309–10): Orchidaceae, Ranunculaceae, Borraginaceae, Cruciferae, Gentianaceae, Halorrhagaceae, Caryophyllaceae, Thymelaeaceae, Campanulaceae, Chenopodiaceae. The largest genus of vascular plants in the flora—namely, *Veronica*—yields only a single record of Heteroptera.

In concluding this section a comparison may be made with Hawaiian conditions, which are more similar than those of Britain. Kirkaldy (1909B, p. 23) writes: "The principal Hawaiian plants, from a hemipterological point of view, are *Nani* (= *Metrosideros*) *polymorpha*, *Pipturus*, *Myrsine*, *Ipomaea*, *Sida*, various tree-terns, *Myoporum*; and to a less degree, *Acacia koa*, *Cyathodes*, *Elaeocarpus*, *Eugenia*, *Freycinetia*, *Dodonaea*, and *Bobea*. Of these, I find on reference to Kirk's great work on New Zealand forest-trees (the only such work I have for reference) that *Cyathodes*, *Elaeocarpus*, *Eugenia*, *Dodonaea*, *Nani*, *Myoporum*, and *Myrsine*—and, I suppose, *Freycinetia*, *Ipomaea*, and *Sida* also—are well represented in New Zealand. It is almost impossible to believe that they too are not the shelters or food plants of a large hemipterous fauna there." Acting on this prophecy, the writer in collecting has always paid particular attention to such of these plants as he has met. Only *Myoporum* and the tree-ferns have proved specially attractive in New Zealand, at least so far as Heteroptera are concerned. Of the other genera, there are scanty records of Heteroptera from only *Cyathodes* and *Freycinetia*.

7. SEASONAL OCCURRENCE.

A very large proportion of the New Zealand heteroptera seem to winter as adults, seeking definite hibernating shelter such as that afforded by the bases of rush clumps (*Juncus effusus* L.), which are shared also to a surprising extent by other wintering Arthropods, including nymph ticks (*Haemaphysalis bispinosa* Neumann). Thus in all our Pentatomidae of which any details are known, in the Cydnidae and Lygaeidae, and perhaps in certain of the Miridae, the imago is the overwintering stage. Most of the European Miridae, according to Butler, pass the winter in the egg—a procedure to which the usual deposition of the ova *within* plant-tissues is perhaps an adaptation. Too little is known of the majority of the New Zealand Mirids to indicate how they spend the winter, but the probability is that most of them resemble their northern cousins in this matter.

Frequently, in species which hibernate as imagines, only one brood is reared in the season, but in some, such as *Arocatus rusticus*, *Nysius huttoni*, *N. clavicornis*, and possibly *Metagerra obscura*, there are strong indications of two or more generations. The water-bugs *Anisops* and *Arctocorisa*, however, and such unrelated families as the Anthocoridae (*Lyctocoris*), Reduviidae (Ploiariinae), and Aradidae, seem to breed all the year round,

or at least in winter as well as in summer. It is evidently no mere coincidence that these five families affect habitats in which conditions change relatively little with the seasons. Their species are certainly exposed less to atmospheric conditions than those of any of the families containing forms which winter only as adults. Moreover, their food-supply would fluctuate less than that of most plant-feeding forms.

In many of the bugs there is thus a definite seasonal movement from hibernation quarters to food-plants in spring, and *vice versa* in autumn, the travelling instar in both cases being the imago. So conspicuous is the endemic Pentatomid *Oncacontias vittatus* at these times that it has won the distinction of the only popular name bestowed upon a Heteropteron in New Zealand—viz., "Little Miss Nothing" (*teste* Mr. E. H. Atkinson).

Seasonal movements of a different kind take place among some of the Aradidae. In the hottest weather of late summer both *Aradus australis* and *Ctenoneurus hochstetteri* take flight in considerable numbers and spread like swarming ants over the countryside. When we consider the similar dispersal habits of cryptozoic social insects such as ants and termites, and when we remember the tremendous companies of Aradidae which habitually congregate beneath limited areas of loose bark, although these assemblages have never to my knowledge been dignified by the title of "societies," the analogy is altogether very striking.

8. ECONOMIC IMPORTANCE.

Without deprecating the probability that all the species have a definite role to play in what J. Arthur Thomson has called "the web of life," the writer has confined his remarks in this section to those forms which exhibit direct and definite economic relationships. Such species are included in the following families: Notonectidae, Miridae, Cimicidae, Anthocoridae, Nabidae, Reduviidae, Lygaeidae, and Pentatomidae. All the remaining families, so far as present knowledge indicates, are entirely negligible economically. Of the eight economic families, the Notonectidae, Nabidae, and Reduviidae contain only beneficial species, the Anthocoridae and Pentatomidae comprise both injurious and useful forms, while the remaining economic families are almost solely injurious.

The Notonectidae are noteworthy enemies of mosquito larvae. The New Zealand species cannot be large enough to be dangerous to even the youngest fish. At the worst, they can only offset the good done in the destruction of mosquito larvae by the devouring of certain quantity of other organisms suitable as food for young fish. Hale has shown that certain Australian Corixidae also feed upon mosquito larvae.

The Nabidae are all predaceous, but exact data as to their prey in New Zealand are lacking. In many cases it is doubtless the nymphs of plant-feeding mirids.

The Reduviidae also are purely predaceous, but, as the common New Zealand members all belong to the subfamily Ploiariinae, containing delicate insects confined to obscure haunts, the insects on which they prey are economically insignificant.

The Anthocoridae are another largely predaceous family; but one species, *Lyctocoris campestris*, has been recorded outside New Zealand as biting man, horses, and cattle. However, the reputation of this species in the Dominion has so far been blameless.

Of the Pentatomidae, both *Oechalia consocialis* and *Cermatulus nasalis* are predaceous and highly beneficial, especially the latter species, which is far more common. *Cermatulus* is especially destructive to Noctuid larvae,

including several important pests of agriculture, and to the pear-slug (*Eriocampoides limacina*). *Zangis amyoti* may become a pest of hedge-plants, though in at least one instance it may be occasionally predaceous. The purely phytophagous species *Dictyotus caenosus* and *Rhopalimorpha obscura* are sometimes exceedingly numerous on meadow-grasses, including cocksfoot.

In the Miridae, the introduced *Stenotus binotatus* is a well-known pest of cocksfoot (*Dactylis glomerata*) and rye-grass (*Lolium perenne*). A species of *Romna* has been observed to feed on a leaf-eating lepidopterous larva.

The Lygaeidae are apparently all phytophagous, but only one has yet been convicted of serious damage: *Nysius huttoni* is a pest of lucerne (*Medicago sativa*).

The Cimicidae are, of course, all parasites of vertebrates. The single species in New Zealand is the introduced bed-bug (*Cimex lectularius*), which is a source of annoyance to man, and may possibly be implicated in the spread of disease.

The Tingidae, which are generally among the most injurious of the Heteroptera, are represented in New Zealand by one very rare species only.

The depredations of sucking-insects like the Heteroptera are immeasurably less spectacular than the wholesale destruction brought about by biting-insects such as locusts and Noctuid larvae. The attack is insidious, and the drain on the plant continuous and weakening, producing added susceptibility to disease. Apart from this, however, there is a rapidly accumulating body of research indicating sucking-insects, and Hemiptera in particular, as agents in the spread of the bacterial, fungous, and "virus" diseases of plants.

9. SPECIES DEALT WITH.

Biological observations, amounting very rarely, however, to anything like a complete life-history, have been made on the following species :—

Arctocorisa arguta
Diaprepocoris zealandiae
Xenophyes cascus
Anisops wakefieldi
Anisops assimilis
Megaloceroea reuteriana
Megaloceroea sp.
Romna capsoides
Romna scotti
Romna sp.
Stenotus binotatus
Eurystylus australis
Cimex lectularius
Lyctocoris campestris
Cardiastethus sp.
Halobates sericeus
Henicocephalus sp. 1
Henicocephalus sp. 2
Reduviolus capsiformis
Ploiariodes rubromaculatus
Ploiaria huttoni
Tingidae n. gen. and sp.
Arocatus rusticus
Nysius huttoni
Nysius clavicornis
Nysius anceps
Nysius n. sp. 1
Nysius n. sp. 2
Nysius n. sp. 3
Metagerra obscura
Orthoea nigriceps
Targarema stali
Margareta dominica
Taphropeltus putoni
Cymodema n. sp.
Neides wakefieldi
Aradus australis
Ctenoneurus hochstetteri
Aneurus brouni
Oechalia consocialis
Cermatulus nasalis
Zangis amyoti
Dictyotus caenosus
Rhopalimorpha obscura
Oncacontias vittatus
Pentatomidae n. gen. and sp.
Hahnia australis
Chaerocydnus nigrosignatus.

The somewhat miscellaneous subject-matter is dealt with under every species in taxonomic order, arranged under the following headings: Copulation; Oviposition; Eggs; Nymphal Instars; Life-history; Seasonal Occurrence; Host Plants, Habitat, and Feeding-habits; Distribution; Miscellaneous Notes.

The New Zealand families are numbered serially, while the number at which each respective family stands in the world list (after Bergroth) is given in brackets.

Family 1 (1). CORIXIDAE.

Arctocorisa arguta (F. B. W.).

Nymphs.

Specimens from Mount Peel are presumably of this species, but as none were bred the identity is not quite certain.

Intermediate Instar.—Length, 3·4 mm. Colour dull brown, eyes darker and appendages lighter. Hemielytral pads projecting out from body, not reaching to level of posterior margin of metanotum (at middle).

Fifth (?) Instar.—Colour as above. Hemielytral pads reaching just past middle of third (dorsal) segment of abdomen, tips of hindwing pads being conterminous. Spine on hind coxae already large, but the tiny supplementary and adjacent one of the imago not yet indicated. One specimen has two black pegs near distal end of intermediate tibia. I can find no such structure in the adult of either sex.

Seasonal Occurrence.

Imagines have been taken in January, February, June to August, October, and November. Fairly advanced nymphs occurred in January. Early in June nymphs were most numerous, but by the middle of July only adults could be found. At Mount Peel in February Mr. Philpott found only nymphs of apparently third, fourth, and fifth instars. There is probably no quiescent (hibernating or aestivating) period, at least in the North Island, but records are not yet sufficient to indicate the number of broods per year. In Britain, according to Butler, Corixids winter as adults, sometimes burying themselves in the mud.

Feeding-habits.

Until 1917 it was commonly assumed that most of the water-bugs, including the Corixidae, were predaceous; but in that year Hungerford published certain results which led him to believe that the common North American forms at least subsisted largely on Algae, which they procure from the ooze at the bottom of their ponds. From his later work (1919, pp. 248–49) is quoted the following summary of his extended experiments: "Corixids sweep in the organic ooze of the pool with its attendant populations, both plant and animal, the bulk of the material being of plant origin. The presence of long filaments of *Spirogyra*, *Zygnema*, and *Oscillatoria* cannot be accounted for in any incidental manner. The deliberate action of the bug in feeding on the chlorophyll of *Spirogyra*, as indicated above, is conclusive evidence of the herbivorous tendencies of these creatures. . . . As a basis for the propagation of Corixids in artificial quarters it has been discovered by experiment that a satisfactory food-supply can be obtained by grinding the water-soaked leaves of cattail that have laid in the marsh over winter and allowing them to reach a state of balance. A brown

flocculent mass is thus produced, in which develop a flourishing population of tiny organisms, both plant and animal. In such a culture *Palmocorixa* has been carried from egg to adult."

Hungerford mentions having seen Corixids catch prey (1919, p. 236), but finds that this does not represent the usual feeding behaviour. On the other hand, Hale (1922, pp. 310–11), experimenting on Australian forms, writes: "For months I kept in aquaria several species of Corixidae, as well as members of Notonectidae and Naucoridae, and during that time they were fed only upon larvae of *Culex fatigans* and *Scutomyia notoscripta*. Even newly hatched Corixidae were observed to capture tiny mosquito larvae, increasingly large examples being taken during the successive stages of the metamorphosis. If, as seems certain, aquatic bugs feed upon these larvae in their native ponds, there is every reason to suppose that they mitigate the mosquito nuisance and are thus of considerable economic importance. The malaria-carrying mosquitoes particularly breed in isolated pools and temporarily inundated grass-grown hollows, localities in which fish do not usually occur, but to which aquatic bugs, possessing the power of flight, have easy access."

As remarked by Hungerford, the feeding-apparatus—both rostrum and forelegs—of Corixids certainly differs very widely from that of the typical predaceous water-bugs.

Distribution.

From the notes on feeding-habits it will be obvious that only fairly stagnant waters can afford a suitable habitat for this species, unless its requirements in this respect differ from those of Corixids in general. Artificial ponds are much favoured.

This insect keeps much nearer the shore than do the Notonectids, and the peculiar and characteristic Corixid coloration of brownish variously marked with blackish renders it almost invisible against the background of a muddy bottom.

Arctocorisa arguta occurs from sea-level to 3,300 ft. (Arthur's Pass), 4,500 ft. (Mount Hector, Tararua Range), and 5,000 ft. (Mount Peel, Nelson). Hutton (1898B, p. 180) records it from Auckland to Otago. The North Island localities are Hawera, Hastings (D. Miller), Wanganui, Tararua Range, and Wellington; South Island—Mount Peel, Arthur's Pass, and Bold Peak (Wakatipu); but these doubtless represent only a small portion of its range.

Miscellaneous Notes.

The attraction of Corixids by light has been often recorded for exotic species. A specimen of *A. arguta* flew into a lighted room at York Bay, Wellington, in February. Hudson (1904, p. 96) found thirteen specimens of this insect among the stomach-contents of nine trout caught in South Canterbury.

Diaprepocoris zealandiae Hale.

In 1922 (p. 8) I wrote, concerning the allegedly doubtful occurrence of *D. barycephala* Kirkaldy in New Zealand, "There are, however, indubitable specimens, labelled 'Auckland,' in the Canterbury Museum." These were probably the specimens which led Hutton to include the species in the *Index Faunae* (1904, p. 224). Kirkaldy (1909B, p. 27) states rather dogmatically that it "has not been taken in New Zealand." More recently,

however, I have seen four specimens of *Diaprepocoris* in the Percy Buller collection of Coleoptera at the Dominion Museum. These were almost certainly taken in New Zealand, but unfortunately they lack data. According to Miss A. Castle and Mr. H. Hamilton, most of Percy Buller's collecting was done in the Wellington and Auckland districts. Mr. H. M. Hale, the authority on Australian water-bugs, is now examining both the Canterbury and Dominion Museum material. He states (*in litt.*) that he has already in the press the description of a New Zealand *Diaprepocoris* distinct from *D. barycephala*, and it seems probable that the eight above-mentioned examples belong to this new species.

Since writing the above I have received from Mr. Hale the following note :—

Diaprepocoris zealandiae Hale.

Diaprepocoris barycephala Hutton, *Index Faunae Novae Zealandiae*, 1904, p. 224 (*nec* Kirk).

Diaprepocoris zealandiae Hale, *Trans. Roy. Soc. S. Aust.*, vol. 48 (1924).

Through the courtesy of Mr. Myers I have been able to examine the four specimens from the Canterbury Museum upon which Hutton's New Zealand record (*ut supra*) was based, and other four examples from the P. Buller collection in the Dominion Museum. *D. zealandiae* was described from a single damaged female; the examples now before me are perfect, and both sexes are represented, so that some little addition to the original description is necessary.

The scutellum is variable in size *inter se*, and is smaller in these specimens than in the type. The hemelytral membrane is not fully developed. Metathoracic wings are wholly wanting in the type, and also in two males which were relaxed and examined for this character; it may be found that metawings are usually absent in this species, but, as I have shown elsewhere, a degeneration of hemelytra and alae cannot be relied upon as a character of specific importance.

In the male the form is more slender, the vertex of the notocephalon is more obtuse, and the eyes are slightly larger than in the female. On the dorsal surface of the male abdomen is a stridulatory apparatus similar to that present in the male of the two Australian species.

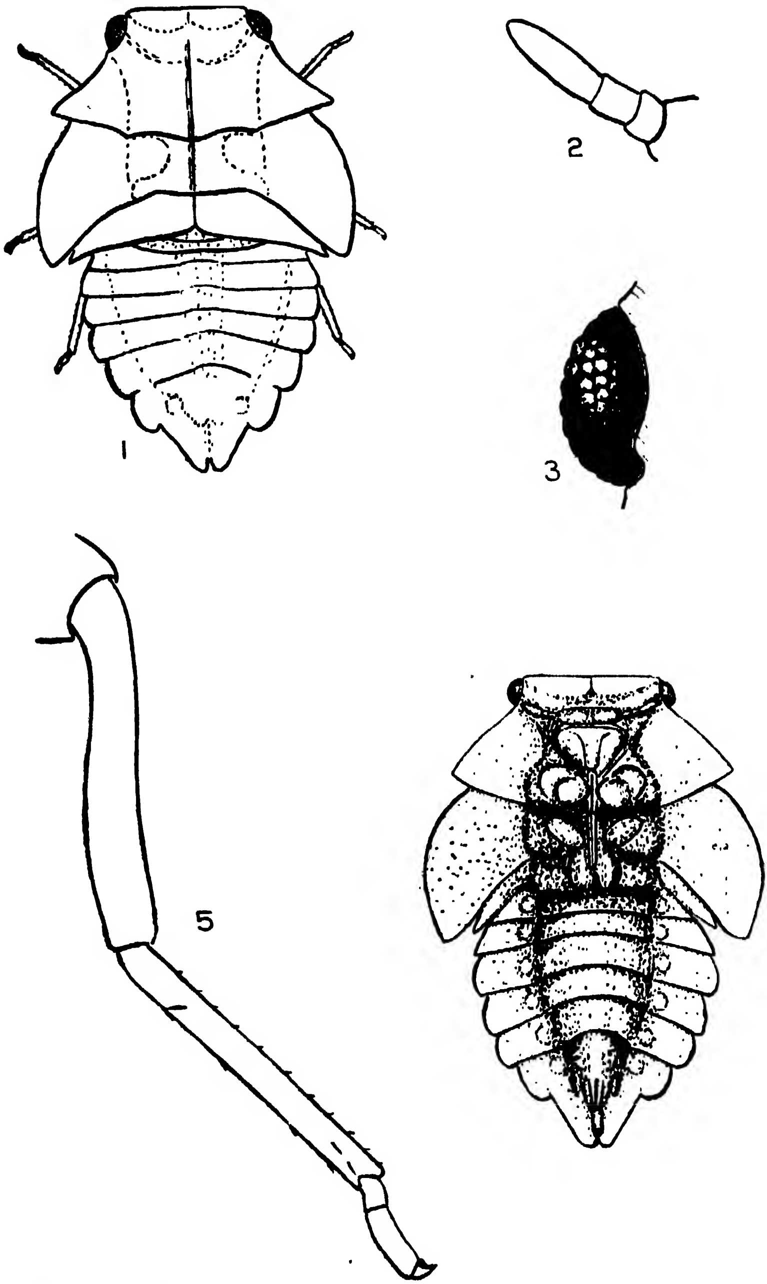
Length, 5 mm. to 6·1 mm. HERBERT M. HALE.

Writing later still, Mr Hales states there are four other specimens in the British Museum from Waitaki (Otago), and another labelled, perhaps wrongly, "Tasmania."

Family 2 (2). PELORIDIIDAE. (Text-figs. 1–5.)

Xenophyses cascus Bergr.

In November, 1920, Mr. H. Hamilton, in sifting leaf-mould for Coleoptera, discovered one nymph and one imago of a new genus belonging to this aberrant family. The adult has now been described by Dr. Bergroth (1924), to whom I am indebted for information on its systematic position and references to the existing literature. In view of the great interest which accrues to the species, from the facts—firstly, that it is only the second known species and genus of the family, the other genus (*Peloridium* Breddin) being confined to the Straits of Magellan; secondly, that the members of the family as a whole are now represented in collections by only four known specimens; and, thirdly, that the Peloridiids exhibit certain morphological features which are apparently distinctly Homopterous, although their nearest relatives are evidently the Ochtheridae (Bergroth), I have thought it advisable not only to describe and figure the nymph, but also to give a few notes on the habitat to which it appears to be confined. Energetic collecting at and around the locality from which the original leaf-mould was procured, although prosecuted on several occasions by Mr. T. R. Harris, who resides in the vicinity, and by Mr. Hamilton, and myself



Figs. 1–5—*Xenophyses cascus:* 1, advanced nymph; 2, antenna; 3, eye; 4, under-surface; 5, metathoracic leg.

The magnifications are not uniform, and the sizes of the various instars are in most cases not comparative; however, the fifth instars of the Pentamoids (text-figs. 12 and 17; Plate 5, fig. 4; Plate 6, figs. 2, 3) are equally magnified.

on several special visits, has so far yielded no more specimens. It may therefore be safely asserted that the bug is very rare. It is of interest to note that the South American species also was collected on the floor of the forest.

(Since the above was written a third genus of Peloridiidae has been described—namely, *Hemiodoecus* China, 1924, from Tasmania; while Dr. Bergroth has received a nymph of unknown species from Lord Howe Island.)

Nymph.

Fourth or Fifth Instar.—For comparison the parts are described in the same order as in Breddin's account of the imago of *Peloridium hammoniorum* (1897, pp. 12–13):—

Length, 2·52 mm.; greatest width (across hemielytral pads), 1·70 mm.

Above flat, abdomen somewhat concave; lower surface convex, except for lateral expansions which are flat. Head with flat straight-edged membranous extension reaching cephalad between the eyes, and with slight median longitudinal ridge extending caudally on to thoracic nota. Pronotum with two wide membranous extensions in the shape of equilateral triangles, one on each side. None of the above membranous areas are areolate. Pronotum seems to be fused with head. Hemielytral pads projecting well out from the body, flat with no signs of venation. At their proximal ends, a long way outside of body proper, they seem to be fused with paranota of pronotum. Abdomen with very wide lateral expansions constricted at segments, of which six ordinary ones are visible on dorsal view, followed by a long conical terminal "segment" notched at tip. What I take to be spiracles are situated on ventral surface of abdomen just near junction of abdomen and connexivum, thus agreeing with *Peloridium* (adult), of which Breddin says, "Stigmatibus a margine exteriore valde distantibus."

Antennae three-segmented, apical segment longest, reaching to mesal border of eyes. Rostrum appearing to arise just cephalad of fore coxae, and extending to hind coxae. Two segments are visible in rostrum, but it is difficult to see whether or not there are further articulations near base. Eyes with large facets. Tibiae of all legs feebly bristly or spinose. Tarsi all appear to be two-segmented with basal segment very short.

Details of pedal, rostral, antennal, and stigmatic characters not obtainable without a certain amount of preparation and dissection, to which I do not propose to subject the unique specimen.

Colour above olivaceous, lateral expansions naturally paler; metanotum suffused with darker; eyes reddish-brown, Below olivaceous, the first four visible segments of abdomen darker than remainder of under-surface; rest of abdomen very pale, but genitalia tinged with yellowish-brown; antennae, legs, and rostrum not appreciably darker than body. Whole surface practically glabrous.

The leaf-mould was gathered in forest near the railway-station of Ohakune, at an elevation of about 2,100 ft. At this spot the dominant tall tree was *Weinmannia racemosa* L., with a sprinkling of *Dacrydium cupressinum* Sol., *Podocarpus spicatus* R. Br., *P. ferrugineus* Don, *Olea Cunninghamii* Hook. f., *Fuchsia excorticata* (Forst.) L., and some *Aristotelia racemosa* (A. Cunn.) Hook. f. nearer the edge. Shrubby undergrowth, represented by a few bushes of *Alseuosmia macrophylla* A. Cunn., *Myrtus pedunculata* Hook. f., *Drimys colorata* Raoul, *Melicytus ramiflorus* Forst., and *Nothopanax arboreum* (Forst. f.) Seem., was extremely sparse. The lowest tier

of vegetation consisted almost solely of *Blechnum discolor* (Forst, f.) Keys, with a few scattered plants of *Microlaena avenacea* (Raoul) Hook. f. and *Histiopteris incisa* (Thunb.) J. Sm. Between the *Blechnum* plants the surface of the very deep layer of leaf-mould was bare; a thick deposit of *Weinmannia* leaves apparently inhibits the growth of mosses and liverworts.*

Since my last visit to the district Mr. Richard Mundy has been so good as to made a detailed botanical survey of the immediate vicinity in which the Peloridiid was taken. He finds that a belt of almost pure *Weinmannia* trees, 30 ft. to 50 ft. high, extends from the bank of the River Mangawhero at least 30 yards into the forest. Farther from the river—say, from 30 to 50 yards—is a belt of more mixed bush, where, although *Weinmannia* is still by far the commonest tree, the large taxads mentioned above become conspicuous. The habitat of the insect in question appears to lie on the border between these two belts; but very scanty data are so far available.

Family 3 (5). NOTONECTIDAE.

Anisops wakefieldi F. B. W.

Seasonal Occurrence.

Adults of this rather rare species have occurred in January and in July.

Distribution.

Hutton records it from Canterbury and Otago, "in ponds" (1898B, p. 180). Kirkaldy (1909B, p. 27) saw specimens from the Chatham Islands. My specimens came from a slow-running stream, shallowed and muddied where it crossed a road, and from a small, very clear lagoon in the sand-dunes of the foreshore, both in the Wellington district. In the stream mentioned *A. assimilis* was also present, and much more numerous; in the second locality *A. wakefieldi*, though not pentilful, seemed to be alone. The sexes were present in about equal numbers.

Anisops assimilis F. B. W.

Seasonal Occurrence.

Adults have been taken in January and August. Very young nymphs were abundant in middle of January, while in June advanced nymphs, almost certainly of this species, were plentiful and almost alone.

Distribution.

Hutton (1898B, p. 180) records this species only from Otago. My specimens have come from Onehunga, Wanganui, and the Wellington district, and in the South Island from Arthur's Pass (3,300 ft.).

The ecological requirements of this species are elastic. It occurs in ponds, in slow-moving streams, in alpine tarns, and in brackish lagoons. The two latter habitats were both stocked apparently only with a form whose entirely black scutellum gave it a strong superficial resemblance

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* For the identification of two of the above plants and for much detailed information on the Ohakune forest, freely imparted, I am indebted to Mr. Richard Mundy.

to *A. wakefieldi.* The tarn in question was a shallow but wide pool, surrounded by typical subalpine bog, and supplied with dark-coloured but perfectly clear water on a bottom of soft flocculent ooze of considerable depth, and with a surface unbroken save by a few large bluish slimy egg-masses of the dragon-fly *Procordulia grayi*. In the water itself *Arctocorisa arguta* (F. B. W.) and a magnificent scarlet water-mite (*Eylais* sp.) were abundant.

The other specimen of the black-scutellumed form was taken in a pool just above high-water mark at Onehunga. The water was thick with *Spirogyra* sp. containing numerous *Ephydra* larvae and the empty puparia of the same fly.

Miscellaneous Notes.

I have previously remarked (1922, p. 9) that "the scheme of coloration is that adopted by many aquatic animals—namely, a shining white, in this case on the dorsal surface, since this is always the under-surface, and a sombre tint on the ventral, which is uppermost (in the ordinary swimming position). The water-boatman is thus more or less invisible when seen from below, with its white dorsum viewed against a light-coloured sky, while, from above, every collector knows how difficult it is to distinguish the insect against the dingy background of the depths." In a muddy pool where both *Anisops assimilis* and *Arctocorisa arguta* were plentiful it was interesting, in connection with a consideration of the colour-scheme, to see how the latter hugged the muddy bottom near the shore, while the *Anisops* is much more wary than *Arctocorisa*.

D. Miller (1920, p. 13, fig. 13) states, "The natural enemies of adult and pre-adult mosquitoes are numerous, Amongst their insect foes occurring in permanent areas of water are the 'water-boatmen,' or *Notonecta* (fig. 13). Experiments were carried out by the writer demonstrating that these insects destroyed large numbers of larvae." Fig. 13 is apparently *Anisops assimilis*.

Fifth-instar nymphs in my collection are probably of this species, but, as they were not reared and thus identified with certainty, description is deferred.

Family 4 (10). ACANTHIIDAE (SALDIDAE).

These are often numerous, but as the species are not yet worked out I cannot give much additional to my previous brief note (1922, p. 8).

In the Hutton collection at Canterbury Museum the specimens labelled "*Salda laelaps*" and "*Salda australis*" are Mirids, some of which are undoubtedly referable to *Romna scotti* (F. B. W.).

Family 5 (13). MIRIDAE (CAPSIDAE).

These bugs are very plentiful in New Zealand, and make up a large proportion of the heteropterous fauna. Until they have been approximately worked out taxonomically very little can be recorded of them. In Britain, according to Butler (1922, p. 201), the majority pass the winter in the egg state. Therefore the plant into which the ova are inserted need not be a food-plant, and in many cases certainly is not. Internal insertion of ova seems to be a provision enabling these very fragile species to carry through the winter. In New Zealand insufficient data are available, but in view of the inexhaustible evergreen shelter—as much available as in summer—it would not be surprising if some manage to winter as adults.

In the Hutton collection at Canterbury Museum are four specimens labelled "*Calocoris laticinctus*": of these, three are *Romna* sp., while the fourth is apparently *Romna capsoides* (F. B. W.).

Megaloceroea reuteriana F. B. W.

Seasonal Occurrence.

Nymphs have been collected in December. Adults occur from November to March. There is therefore a strong probability that this bug passes the winter in the adult stage.

Host Plants.

M. reuteriana has been swept from pasture and from marram-grass (*Ammophila arenaria* (L.) Link.), the latter being much favoured. The linear form and striped coloration are strong evidence of its practically exclusively graminicolous habit.

Distribution.

North Island localities range from North Auckland through Lake Taupo (E. H. Atkinson !) to Wellington. In the South Island it has been collected at Mount Grey (J. W. Campbell !) and Governor's Bay (J. F. Tapley !). Hutton (1898B, 176) records it from Canterbury.

In the central plateau of the North Island it ascends at least to 3,000 ft. (E. H. Atkinson).

Megaloceroea sp.

This green species, which occurs on cocksfoot (*Dactylis glomerata* L.) at Wanganui in December and January, is mentioned here chiefly in order to correct a passage in which the writer wrongly recorded it as a Nabid (Myers, 1922, p. 6). It has occurred also at Auckland on *Juncus lampocarpus* Ehr., in February.

Romna capsoides (F. B. W.).

I have seen a specimen collected at Wainuiomata, 25th December (G. V. Hudson).

Romna scotti (F. B. W.).

This is not the *R. scotti* mentioned in Myers, 1922 (p. 8).

Seasonal Occurrence.

Adults have been collected in April, and October to January.

Host Plants.

Miscellaneous undergrowth must be included here, but especially *Urtica ferox* Forst f. and *Muehlenbeckia australis* (Forst. f.) Meissn., also *Coprosma robusta* Raoul.

Distribution.

This is a common species at Wellington and at Arthur's Pass (3,000 ft.). Hutton (1898, p. 177) gives the range as "Canterbury and Otago." The writer has taken it also at Wanganui and at Kohukohu (Hokianga).

Romna sp.

This brilliant reddish species, larger than *R. scotti*, is apparently attached to manuka (*Leptospermum scoparium* Forst.), where both adults and nymphs are often abundant throughout the Wellington district. In February a small green caterpillar, probably the larvae of *Ctenopseustis obliquana* (Walk.), was suspended by its silken thread from the manuka, with one of these bugs sitting on it. In capture they were unfortunately separated, but the *Romna* searched assiduously, with outstretched rostrum, apparently for the caterpillar, on which it had almost certainly been feeding. This species was incorrectly determined by me as *R. scotti* (Myers, 1922, p. 8). A second species of *Romna* was taken on the snow on Mount Ruapehu in January, 1924, by Mr. T. R. Harris. The exact elevation was not ascertained, but was probably about 7,000 ft.

Stenotus binotatus (Fabr.).

" The egg is of the usual Capsid type, with a well-developed collar at the anterior end " (Butler, 1923, p. 409).

Seasonal Occurrence.

In Europe the adults occur from May to October, and the nymphs up to the end of June (Butler, 1923, p. 409). In New Zealand the adult appears in October, is plentiful in November, excessively abundant in December and January, and occurs also in February. Nymphs are plentiful in January. Absence of adults in autumn, coupled with the fact of internally deposited eggs, points to ovum being the wintering stage, as in many Miridae in Europe.

Host Plants and Feeding-habits.

S. binotatus is essentially a frequenter of grasses, chiefly the introduced English species, including cocksfoot (*Dactylis glomerata* L.) and perennial rye (*Lolium perenne* L.). On these it occurs in almost incredible numbers. " The insects may be seen inserting their beaks into the heads of the grasses, and moving quietly round to the opposite side when approached too closely. The imagines take wing very readily." (Myers, 1922, p. 8.)

In Europe " it is a common wayside insect, found on grasses and other plants both there and in rough meadows. The only plants given by Reuter (12) besides grasses are *Chrysanthemum leucanthemum* and *Erica*." (Butler, 1923, p. 409.)

In North America Howard (1893, pp. 90–92) has indicated it as a serious pest of timothy-grass (*Phleum pratense* L.)—" almost every head examined carried from six to fifteen bugs."

Distribution.

This very common species was certainly introduced from Europe. " It is found over Europe, Asia Minor, and Syria, and also in North America, where it sometimes does damage to grasses; it extends also into the Ethiopian region. In Britain it is often a very common insect and is fairly widely distributed, being recorded from twenty-six English counties . . . and it is found in Ireland, but there are no records from Scotland." (Butler, 1923, p. 410.) In New Zealand it is plentiful in the North Island

from the extreme north (Te Paki), Hokianga, and Auckland to Raglan (Miss Parker), Taupiri (T. Cockcroft), Waitomo (C. E. Clarke), Makatote (D. Miller), Ohakune (T. R. Harris), Hastings, Wanganui, Greytown, and Wellington; and in the South Island at Nelson, Riwaka (David Miller), Canterbury, and the West Coast (T. R. Harris). At Ohakune it ascends to 2,100 ft.

Miscellaneous Notes.

"This is a most variable species; there is not merely the very different coloration of the sexes, but each of these varies indefinitely, especially as regards the amount and intensity of the black markings" (Butler, 1923, p. 409). It is probably sufficiently numerous on and destructive to pasture grasses to be considered a pest.

Eurystylus australis Popp.

Seasonal Occurrence.

Adults have been collected in February and March.

Host Plants.

This species has inflicted very serious damage on passion-vine (*Passiflora edulis* Sims), and has been taken also on apple, and frequently on grasses. On passion-vines the shoots are attacked.

Distribution.

Dr. Bergroth, who kindly identified this species, writes that it was "described from Botany Bay, Sydney, and is apparently imported from Australia into New Zealand." In New Zealand it occurs in the Auckland (including Waikumete and Henderson) and Nelson (A. Philpott) fruit-growing districts.

Family 6 (17). Cimicidae.

Cimex lectularius Linn.

The bed-bug, although introduced into New Zealand by the agency of the white man, is very much more widely distributed than the four records—Pukehuia (North Auckland, in June, David Miller); Wanganui; Wellington (January); and coastal passenger-steamers—would imply. It is practically a cosmopolitan species.

Family 7 (19). Anthocoridae.

Individuals of this family are abundant, particularly among dead leaves, and in the "beards" or dead hanging fronds of the large tree-fern *Cyathea medullaris* (Forst. f.) Sw. None of these presumably endemic species have yet been identified.

Lyctocoris campestris (Fabr.).

Egg undescribed (Butler, 1923, p. 323).

Nymph.

An intermediate instar—" ovate, reddish-testaceous, with a clear testaceous margin to the whole of the body behind the head; head convexly triangular, rather longer than broad at base; pronotum trapezoidal, transverse, rather convex on disc and explanate at margins; wing-pads quite small; the whole surface finely punctate and pubescent, except down centre of dorsum; where it is finely transversely striate; legs and antennae testaceous; tarsi two-jointed, basal joint very short.

" Later instar, 3 mm. Similar to the above, but with larger wing-pads. The whole body is more or less shiny." (Butler, *l.c.*)

Seasonal Occurrence.

In Europe " the imago is found practically all the year round . . . the indications are that there are specimens which reach maturity at various times during the spring and early summer months, although no doubt the majority belong to the brood which matures in August." (Butler, *l.c.*)

In New Zealand adults and fourth- and fifth- stage nymphs occurred together in August.

Habitat and Feeding-habits.

In England " they are found most abundantly in the thatch of hay, straw, and bean stacks, and also in the refuse of the stacks and in granaries . . . Probably any kind of vegetable rubbish will form a suitable nidus for them." (Butler, 1923, p. 324.)

" Parfitt found it feeding on the larva of a species of *Thrips* . . . The insect can inflict a sharp prick with its rostrum. Reuter maintains that it was originally a vegetable feeder, living in the open, but that, being introduced into stables and cattle-stalls with straw, it then abandoned its vegetarian habits and became a blood-sucker on both horses and cattle." (Butler, *l.c.*)

The writer found nymphs and imagines very common on the white-washed walls and roof of a cow-shed, in the bails, and especially in the folds of the cow-covers which were taken off the animals during the warmth of the day. They were so abundant that it was difficult to understand on what they could be feeding. I think it would have been noticed had they been biting the cattle. Most of the cows had a few lice, *Trichodectes scalaris* Nitzsch, but these were hardly plentiful enough to form the main food-supply, even if attacked. In captivity the adults preyed readily on green spruce-aphis (*Myzaphis abietina* (Walk.)).

Distribution.

" Spread all over the Continent and in North Africa and Syria, it inhabits also the Oriental, Nearctic, and Neotropical provinces. It is probably also one of the commonest Heteroptera we possess in this country. . . It has spread even to New Zealand (Buchanan White, 4), and Wollaston found it in St. Helena (Buchanan White, 6)." (Butler, *l.c.*)

In the New Zealand region it occurs at Aramoho (Wanganui), and on Sunday Island, Kermadec Archipelago (W. L. Wallace !).

In view of its very wide distribution it is difficult to say whether it is indigenous here or introduced, but it is probably introduced.

Family 8 (22). GERRIDAE.

Halobates sericeus Esch.

The only known occurrence of this oceanic bug in the waters of the New Zealand region was recorded by the writer (1921c, p. 257). In this instance six females and twelve males were found on the beach at Denham Bay, Sunday Island, Kermadec Islands, by Mr. W. L. Lawrence, in 1908.

Family 9 (23). VELIIDAE.

Some confusion exists between the species, at least two (*Microvelia*) occurring in New Zealand. Until this is clear little can be profitably recorded of their bionomics.

Family 10 (27). HENICOCEPHALIDAE.

Henicocephalus.

The New Zealand species, of which there are at least two, are being revised by Dr. Bergroth.

Egg. (Text-fig. 6.)

One egg laid in the middle of January was more or less elliptical, with parallel sides and rounded ends, much longer than thick, and of a beautifully frosted white appearance. After preservation in alcohol the chorion appear perfectly colourless and transparent with a very faint indication of pitting; this may have been due to contents. The egg was fastened firmly by its side to a rootlet. In the course of a couple of days it shrivelled completely, showing probably that it was not fertilized. This egg was laid by a large specimen from leaf-mould at Ohakune (2,100 ft.).

Seasonal Occurrence.

Nymphs have been taken in October, November, and January; adults from December to February.

Distribution.

Specimens have been examined from Pokaka (D. Miller), Ohakune (T. R. Harris, H. Hamilton, J. G. Myers), and Wellington district (T. Cockcroft, G. V. Hudson, J. G. Myers), all in the North Island; and a smaller species (?) from Reefton, in the South Island (A. L. Tonnoir). The North Island species occurs up to 2,100 ft.

Miscellaneous Notes.

That these bugs are in the habit of flying in groups about sunset or even in the late afternoon sun, frequently hovering like gnats, is well known. Mr. Harris (Jan., 1924) saw several swarms on a cloudy morning, and caught thirty or forty examples with one sweep of the net.

The habitat of the larger common North Island form appears to be only the leaf-mould of the forest-floor. The small South Island form collected by Mr. Tonnoir was, on the other hand, found under bark, in company with its nymphs.

In captivity the North Island species throve well in leaf-mould. When touched, these specimens would rear up the head and thorax into a

vertical position and hold out, wide apart, the powerful first pair of legs, with the tibiae bent at about right angles to the femur. With these legs striking motions were frequently made. When the winged forms act thus the soft membranous hemielytra are bent almost at right angles at about one-third from their base. This would be impossible in normal Heteroptera.

In ordinary walking the long and peculiar head is turned from side to side in a way very reminiscent of a mole-cricket (*Gryllotalpa*), except that in the latter it is the prothorax plus head which moves thus. They cannot walk up a vertical glass surface.

Family 11 (28). NABIDAE.*

Reduviolus capsiformis Germ.

Seasonal Occurrence.

Adults have been taken from January to April (Canterbury).

Host Plants.

It has been taken "amongst weeds" (W. L. Wallace), on grasses, lucerne (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.), and on a sward of *Juncus lampocarpus* Ehr., interspersed with *Sparganium subglobosum* Morong and *Cyperus* sp.

Distribution.

This is the most abundant and widely distributed Nabid in New Zealand. Hutton (1898, p. 178, under name *Nabis saundersi*, which Dr. Bergroth informs the writer is a synonym) gives the range as Auckland to Otago. The writer has seen specimens from the Kermadec Islands (W. L. Wallace), Kaitaia, Whangarei, Auckland, and Wellington; and in the South Island from Blenheim, Nelson (including Dun Mountain), and Governor's Bay.

N. capsiformis is an almost cosmopolitan species.

Family 12 (29). REDUVIIDAE.

Pirates ephippigera (White).

It seems to me extremely doubtful whether this Australian species occurs in New Zealand. Neither Hutton, Buchanan White, nor myself saw specimens from this country, nor, apparently, did Kirkaldy.

Ploiaria huttoni (Scott).

Eggs.

Eight eggs were deposited by a female in autumn. Soon after the completion of oviposition the female died. The eggs were laid on the surface of the cork stopping the mouth of the tube in which the insect was confined. Some were glued firmly by their length to the plane surface; others were deeply inserted into crevices in the cork, only the collared end visible.

* Dr. Bergroth informs me that the correct orthography is *Nabididae.*

The shape of the eggs is shown in fig. 7. Surface without sculpture, or with a faint trace of pitting, primarily smooth, colourless and transparent, but covered, more in some eggs than in others, with a black soot-like deposit, removable without difficulty. One or two eggs were quite black and roughened with this material.

Length, 0·8 mm.; greatest width, 0·3 mm.

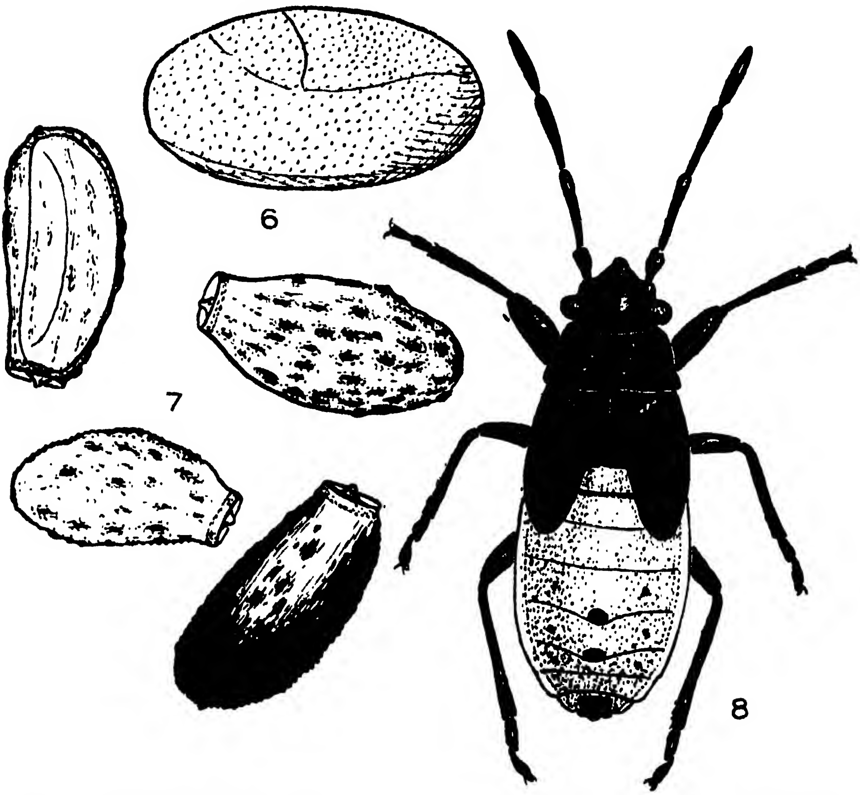


FIG. 6.—*Henicocephalus* sp.: egg. FIG. 7.—*Ploiaria huttoni*: eggs. FIG. 8.—*Arocatus rusticus*: fifth instar.

Occurrence and Distribution.

I have two specimens, a male and a female, taken by Mr. W. R. B. Oliver in a shed at Seatoun, Wellington, in April. Hutton (1898, p. 179) gives as localities Auckland and Wellington. Bergroth (1923, pp. 398–99) has recently recorded it from the Island of Juan Fernandez. He states, "The occurrence of this wingless New Zealand species on Juan Fernandez is one of the proofs of the existence of an ancient land connection between New Zealand and Chile."

Ploiariodes rubromaculatus Blackburn.

Seasonal Occurrence.

Adults have been collected in November, January, February, April, and May.

Host Plants and Habitat.

This species has been beaten from the foliage of *Citrus grandis* (L.) Osbeck (poor-man orange) and from *Blechnum filiforme* (A. Cunn.) Ellingh., clothing a tree-trunk; but the greatest numbers may be secured from the dead hanging fronds of tree-ferns, especially *Cyathea medullaris* (Forst. f.) Sw. and *Dicksonia squarrosa* (Forst. f.) Sw. The former tree-fern (Plate 81, fig. 1) retains much more of its dead foliage than any of the others, and shows at all times a heavy beard offering splendid shelter for insects of many orders, including Lepidoptera (adult Noctuids, Selidosemids, and various "micros"), Psocoptera, Diptera (*e.g.*, Tipulidae), Coleoptera, Heteroptera (Anthocorids, Ploiariinae).

One specimen was found in November on the side of a cottage in the forest.

Distribution.

I have seen specimens from Whangarei and the Wellington district in the North Island; and from Tisbury (A. Philpott), and Moutere, Nelson (R. J. Tillyard).

Bergroth (1923, p. 398), in recording it from Juan Fernandez, writes: "This species is almost cosmopolitan. It was originally described from Hawaii, and has since been described under different names from the Fiji Islands, California, and New South Wales. Mr. J. G. Myers has recently sent me specimens of it from New Zealand, and Mr. Malloch . . . informs me that he knows the species also from the Atlantic coast of U.S.A. and from Madeira."

There is another species from Nelson, now being described by Dr. Bergroth.

Family 13 (31). Tingidae.

There is a correction to make in my remarks on this family in New Zealand (1922, p. 6). The supposed Tingid mentioned as collected in leaf-mould by Mr. H. Hamilton has nothing to do with this family. The only New Zealand species so far discovered is the one recorded in the footnote (*l.c.*, p. 6), collected by the writer on sedges in Gollan's Valley, Wellington, 5th February, 1921. I have recently received three additional specimens as a generous gift from Mr. G. V. Hudson, who took them in the Karori Reservoir Reserve, Wellington, probably from *Cassinia leptophylla*, on 8th March, 1924. This species is being described by Dr. Bergroth.

Family 14 (34). Lygaeidae (Myodochidae).

This very numerous family includes both leaf-mould-dwelling and plant-haunting forms, but most of the latter show a decided preference for low-growing vegetation.

Arocatus rusticus Stal.

This beautiful species has not been reared through all its stages, but the Misses Hursthouse have carried it over from fifth instar to imago. The following instars are therefore delimited without absolute certitude. (Plate 82, figs. 1–3, and text-fig. 8.)

First Instar (Plate 82, fig. 1).—Head, pronotum, and mesonotum blackish-brown; on metanotum only two lateral heavily chitinized triangles are dark; rest of metanotum and greater part of abdomen crimson; two black scent-gland areas small and elliptical; genital segment black.

Antennae almost as long as body, hairy; posterior margin of mesonotum straight or very slightly convex, caudad in middle; rostrum reaching middle of abdomen. Shape long and narrow; thorax parallel-sided; abdomen somewhat wider. Length, 2·1 mm.

Second Instar.—Similar in colour and proportions; rostrum reaching not quite to middle of abdomen. Length, 2·4 mm.

Third Instar (Plate 82, fig. 2).—Head, pronotum, mesonotum, and appendages blackish-brown; a narrow median longitudinal pale line sharply demarcated down thorax; dark chitinized sclerites of metanotum relatively smaller in extent; abdomen as in previous instars; rostrum reaching nearly to mid-abdomen; underside almost entirely red; exterior angles of mesonotum very slightly produced caudad. Length, 3·0 mm.

Fourth Instar (Plate 82, fig. 3).—Colour as in previous instar. Rostrum reaching base of abdomen. Abdomen with row of small depressed black spots down each side of dorsum. Hemielytral pads extending just past posterior edge of first abdominal tergite. Length, 4·7 mm.

Fifth Instar (Text-fig. 8).—Considerably elongated; rostrum still reaching base of abdomen; hemielytral pads nearly attaining middle of third tergite. Length, 7·7 mm.

Some of the nymphs exhibit oligomery of the antennae; in other words, one of these organs may show fewer than the usual number of segments together with a lengthening of certain of the segments that remain. In view of Butler's remarks that brachyptery and antennal oligomery are associated usually with ground-dwelling habits, the occurrence of the latter phenomenon in a practically entirely arboreal species like the present one is of great interest.

Seasonal Occurrence.

All instars, including adult, have occurred in April, third and fourth instars have been taken in March, fifth in March, and imagines in September, November, December, and April.

Host Plants.

Specimens found in early September under the bark of dead kahikatea (*Podocarpus dacrydioides* A. Rich.) were probably hibernating. The favourite food-plant is certainly *Parsonsia*, especially *P. heterophylla* A. Cunn., on which nymphs and adults are always to be found in their respective seasons.

Distribution.

Hutton (1898B, p. 173) states that the range is from Auckland to Otago. The writer has seen specimens from Manakau (D. Miller), Wanganui, Waikanae (D. Miller), and Wellington district (T. Cockcroft, J. G. Myers), all in the North Island. Kirkaldy (1909B, p. 25) writes, "A common Australian species. I have recorded it from French Pass" (South Island).

Nysius huttoni F. B. W.

Life-history.

At the last ecdysis the cuticle splits along the median longitudinal line of the thorax, the fissure extending along the posterior margin of the head, and forward between the vertex and the eyes.

Seasonal Occurrence.

Adults of this small species have been taken during November to April inclusive, with a maximum during the three summer months. Nymphs have occurred in March and April, the three older instars in the latter month. There is probably more than one brood per year.

Host Plants.

N. huttoni occurs on ground herbage and on the ground itself. It has been taken from the following plants and grasses: *Cassinia leptophylla* R. Br., *Medicago sativa* (lucerne), and *Linum* sp.

All stages were swept in considerable numbers from lucerne. In one case, in the Wellington district, they had apparently done considerable damage to the crop, which was extremely patchy. The areas of poor crop, making up about seven-eighths of the half-acre, were covered with stunted, dirty-coloured plants, and the bugs were in evidence, both nymphs and adults, on the surface of the soil, which was dusty and drier and consequently warmer than that of the healthy patches protected by the taller and closer plants. The species of *Nysius* are noteworthy sun-lovers. In Blenheim in the previous March large numbers of the bug were swept from lucerne; but here in April (same year) no specimens were obtained by sweeping, owing to the insects keeping more to the ground. In the good patches of lucerne not a bug could be found, either on the plants or on the ground. In the stunted areas, on the other hand, they were in large numbers; and, according to the owner, had been present in phenomenal swarms a month previously. Although it could not be proved that all the damage was attributable to *Nysius huttoni*, there was no reasonable doubt that it had been an important factor.

Distribution.

Hutton (1898B, p. 173) writes: "Canterbury and Otago, common, running on the ground in gardens, &c." Specimens have been collected at Te Paki (extremest north), Kaitaia, Whangarei, Auckland, Ohakune, Hastings, Levin, and Wellington, in the North Island; and at Stephen Island (R. J. Tillyard), Blenheim, and Central Otago, in the South. It is thus widely distributed throughout both Islands. Kirkaldy (1909B, p. 25) has recorded it from the Chatham Islands. On the Tararua Range it is plentiful up to an altitude of 5,000 ft.

Nysius clavicornis (Fabr.).

Seasonal Occurrence.

Adults taken in September in dead kiekie (*Freycinetia*), and in October on more than one occasion *in copula*, seem to indicate hibernation in the imaginal state. The adult has been collected from September to April

inclusive, with a maximum of abundance in January. There is probably more than one brood per year. Third-instar nymphs have occurred in late summer.

Host Plants.

Grasses, *Metrosideros scandens* Sol., *Fuchsia excorticata* (Forst.) L., *Cassinia leptophylla* R. Br., and dead foliage of *Dacrydium cupressinum* Sol. and of *Freycinetia Banksii* A. Cunn. have all yielded this widely ranging and abundant species. In gardens it is often extremely plentiful on the flowers of garden marguerite (*Chrysanthemum* sp.). On *Cassinia* it is the flowers that attract it.

Distribution.

In the North Island it has been taken at Whangarei, Ohakune ? (T. R. Harris), Pokaka (D. Miller), Lake Taupo (E. H. Atkinson), Mount Ruapehu (Miss Stella Hudson), Hastings, Wanganui, Tararua Range, and Wellington ; in the South Island at Stephen Island (R. J. Tillyard), Nelson (A. Philpott), Greymouth (R. Helms), Dun Mountain, Motueka (T. Cockcroft), Dunedin (W. G. Howes), and Lake Wakatipu (G. V. Hudson). Hutton (1898B, p. 173) writes, " Auckland to Otago ; common in Auckland, in gardens."

On the Tararua Range (Mount Hector) it ascends to the highest level—viz., 5,000 ft. Miss Stella Hudson (1922, p. 94) found specimens on a glacier on Mount Ruapehu at an elevation of 7,500 ft. under circumstances which may be described in her own words :—

" On January 11th, 1922, during an attempted ascent of Ruapehu, a slightly active volcano, 9,000 ft. high . . . I had the good fortune to observe many hundreds of insects stranded on a glacier at a height of 7,500 ft. Five orders were represented among the insects thus seen. They were all lowland forms, and must either have been blown up from the surrounding plains, or, as I think more probable, were migrating across country. It has been previously observed that insects occasionally congregate on mountain-tops during migration. Ruapehu is the highest summit in the North Island, and is surrounded by many miles of undulating forest and tussock-clad country, practically in its primitive condition, and ranging from 2 000 ft. to 4 000 ft. in height above sea-level. It thus seems highly probable that insect swarms should occur on this mountain. At first sight I thought the glacier was covered with fine dust, but on a closer examination the ' dust ' proved to be minute dipterous insects."

The other orders represented were Coleoptera, Lepidoptera, Odonata, Perlaria, Trichoptera (plus the two previous listed as Neuroptera), and Hemiptera. The deposit apparently consisted entirely of winged insects. The writer is inclined to agree with the first suggestion made—that the insects were blown to this unaccustomed elevation by the wind.

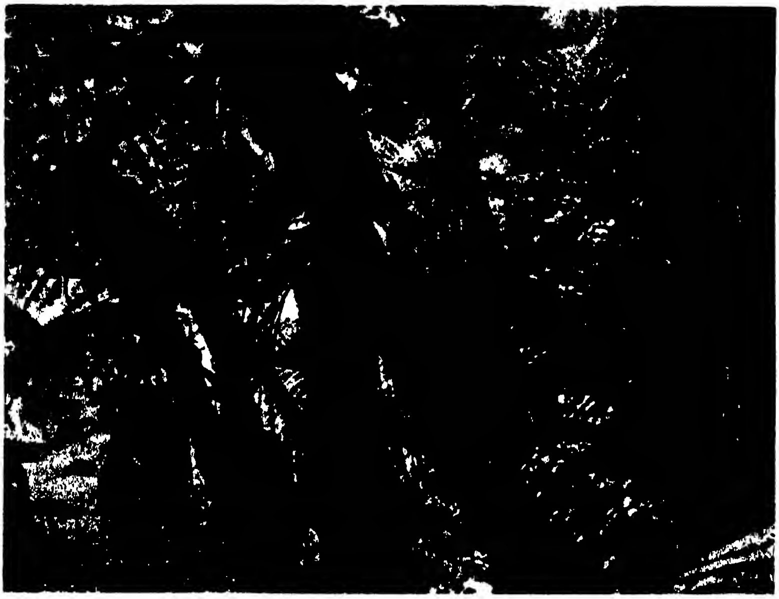
Nysius anceps F. B. W.

Seasonal Occurrence.

Imagines have occurred from August to November, January, and March. The August specimens were hibernating under bark.

Host Plants and Habitat.

It is usually swept from grasses and rushes. One specimen was taken in a house. Hibernating adults have been found under bark of blue-gum (*Eucalyptus globulus* Labill.).



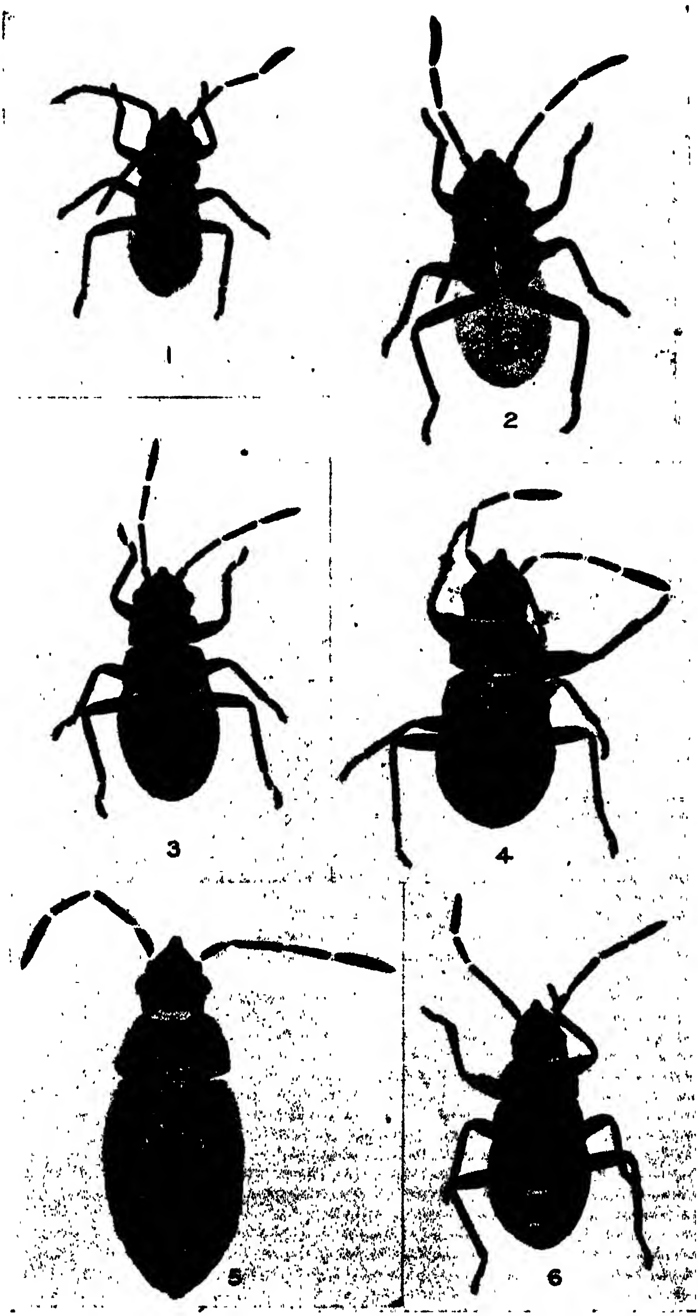
[E. B. Levy, photo.

Fig. 1.—Grove of mamaku (*Cyathea medullaris*).

[J. G. Myers, photo.

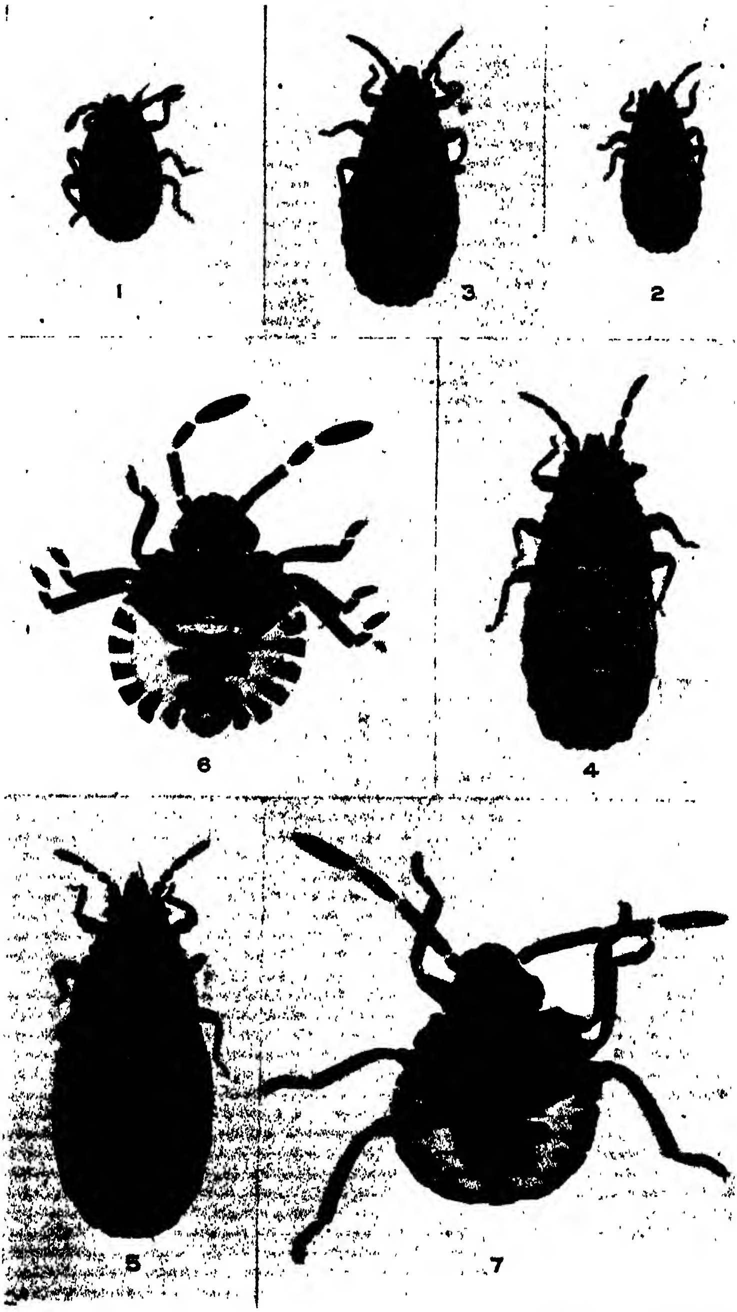
Fig. 2.—Rushes, or wiwi (*Juncus effusus*), in pasture.

Face p. 489.]



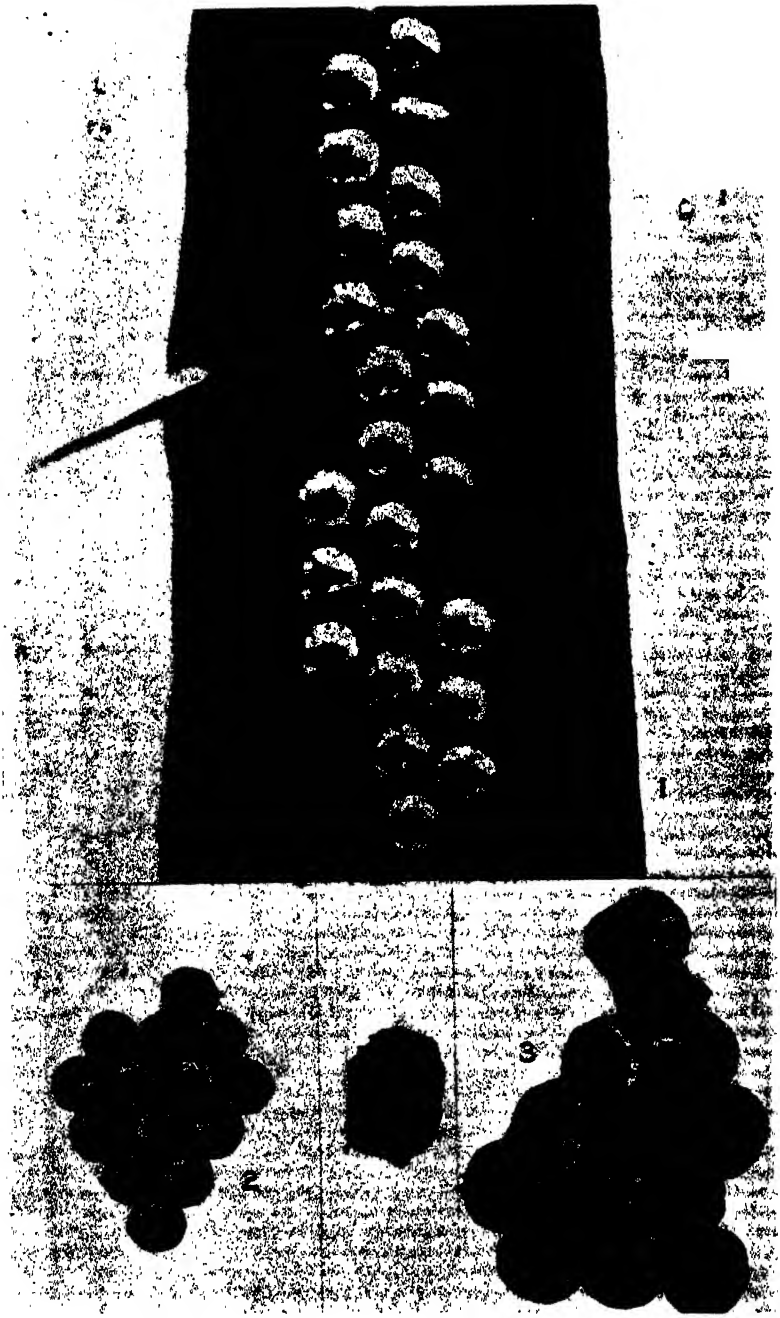
[W. D. Reid and H. Drake, photo.

FIGS. 1–3.—*Arocatus rusticus*: 1, first instar; 2, third (?) instar; 3, fourth instar.
FIGS. 4–5.—*Orthoea nigriceps*: 4, intermediate instar; 5, fifth instar.
FIG. 6.—*Margareta dominica*: intermediate instar.



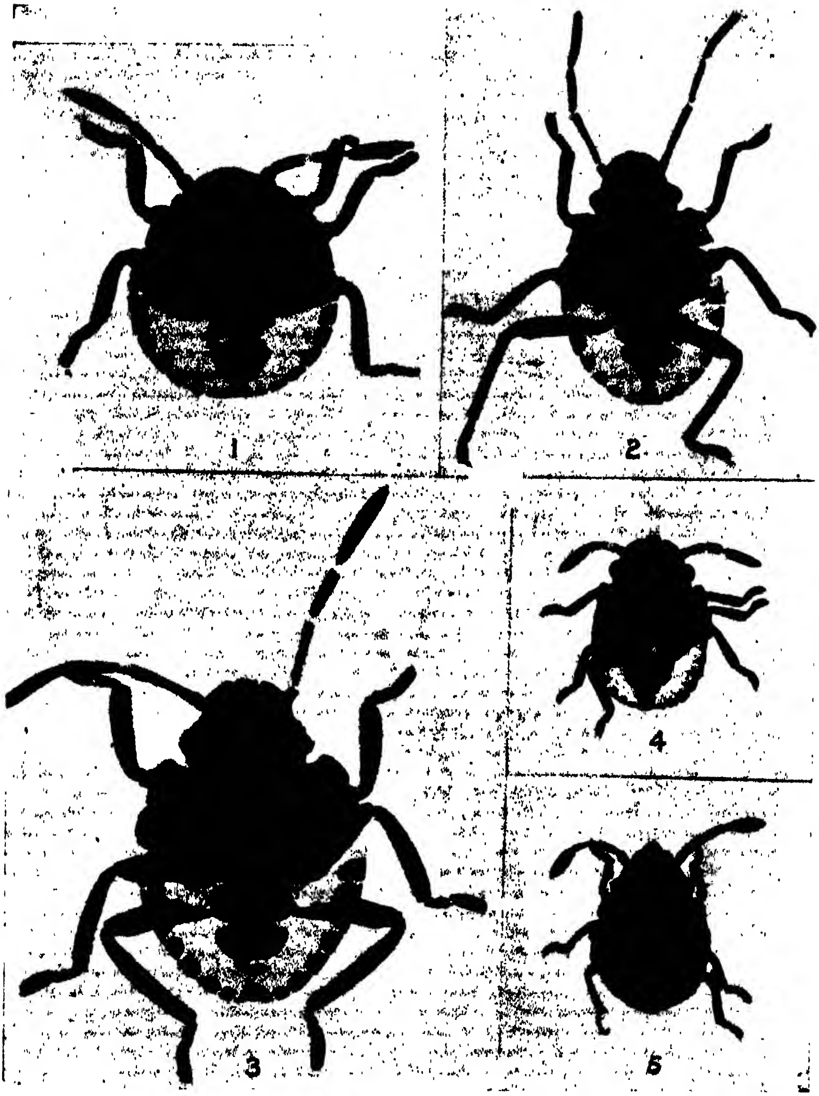
[*W. D. Reid and H. Drake, photo.*

Fig. 1.—*Ctenoneurus hochstetteri*: second instar.
Figs. 2–5.—*Aneurus brouni*: 2, second instar; 3, third instar; 4, fourth instar; 5, fifth instar.
Figs. 6–7.—*Cermatulus nasalis*: 6, first (?) instar; 7, second instar.



[W. D. Reid and H. Drake, photo.

FIG. 1.—*Cermatulus nasalis*:
FIG. 2.—*Zangis amyoti*: eggs.
FIG. 3.—*Dictyotus caenosus*: eggs.



[W. D. Reid and H. Drake, photo.

FIGS. 1–3.—*Zangis amyoti*: 1, first instar (KOH preparation); 2, second instar; 3, third instar (much less magnified).
FIG. 4.—*Dictyotus caenosus*: first instar.
FIG. 5.—*Rhopalimorpha obscura*: second instar.

[W. D. Reid and H. Drake, photo.

FIG. 1.—*Rhopalimorpha obscura*: intermediate instar.
FIGS. 2–3.—*Oncacontias vittatus*: 2, second instar; 3, third instar.

Distribution.

The only North Island specimens seen by me were collected in the Wellington district, where it is not uncommon. In the South Island it has occurred in Canterbury (Hutton), and more specifically at Little River (T. Lee), Darfield (J. G. M.), Governor's Bay, Timaru (J. W. Campbell), Stephen Island (R. J. Tillyard), and Greymouth (R. Helms).

Miscellaneous Notes.

This species appears invariably to be brachypterous. I have seen no variation in this condition towards either longer or shorter hemielytra.

Nysius spp.

Four or five species of this genus are in the hands of Dr. Bergroth for description.

One species, very common in the Wellington district, is confined apparently to tauhinu, or cottonwood (*Cassinia leptophylla* R. Br.). A second species is specially attached to *Raouli tenuicaulis* Hook. f., and has been collected on the Tararua and Rimutaka Ranges from sea-level up to 4,000 ft., and at Arthur's Pass up to 3,800 ft. Adults occur also on the flowers of *Angelica montana* (Forst.) Cockayne. In September incalculable thousands were found clustered on the summit of Mount Matthews (lower Rimutakas, 3,000 ft.) beneath stones and under the boards of the old and broken trigonometrical station. In November the bugs were swarming on the open flowers of *Raoulia tenuicaulis*, many being found *in copula*. These two facts indicate hibernation in the adult stage. Towards the end of December and during January all stages of nymphs are abundant on the same *Raoulia* plants. The bugs run actively on these mat-plants and over the sun-warmed stones between them.

A third species of *Nysius* appears to be purely subalpine in distribution. It has occurred at Arthur's Pass from 2,600 ft. to 3,500 ft., at Lake Wakatipu (G. V. Hudson), and at Gouland Downs (2,500 ft.) (R. E. Grimmett), in November, December, and January. It is very abundant on the flowers of *Celmisia coriacea* (Forst. f.) Hook. f., and in December may be found *in copula* in this situation both during the day and at 8 p.m. At night they were extremely sluggish and gave every indication of spending the night in these great flower-heads.

One undescribed species, much smaller than the other described New Zealand species, has been found on *Juncus* at Ashburton (South Island) by Mr. W. W. Smith.

Metagerra obscura F. B. W.

Seasonal Occurrence.

Adults have occurred in July, October to January, and in April, with one maximum of abundance in October and another in January. There may therefore be two broods per year. The conditions of life in such a cryptozoic species are probably very uniform, and the influence of the seasons perhaps not great.

Host Plants and Habitat.

It is rare for this little species to occur anywhere else than in the leaf mould of the forest-floor, where it is one of the most plentiful species; but it has been taken also on *Gahnia* sp., on *Muehlenbeckia* sp., and on ferns

Distribution.

Owing to its cryptozoic habitat this bug is probably overlooked in many localities where leaf-mould has not been sifted, and the range is almost certainly wider than the present records indicate. In the North Island it has been taken at Ohakune (T. R. Harris), Porirua, and Wellington district; in the South Island at Otira (T. Cockcroft), and in Canterbury (Hutton). Dr. Bergroth has received it from Greymouth, on the west coast, where it was taken by the late R. Helms.

Orthoea nigriceps Dall. (Plate 82, figs. 4, 5.)

Nymphs.

An Intermediate Instar (Plate 82, fig. 4).—Head black, eyes dark reddish-brown; pronotum black with two yellow spots at middle of posterior border, edges paler; mesonotum blackish with two yellow spots on middle of fore-border, two smaller laterad of these and two on posterior border; a very narrow but distinct median longitudinal pale line on mesonotum; hemielytral pads reaching posterior edge of metanotum, blackish with paler edges externally; metanotum black with two yellow spots at middle of hind-border and a continuation of pale median longitudinal line of mesonotum. Abdomen with three dark scent-gland areas separated by zones tinged slightly with reddish; connexivum marked with one large pale spot in each segment; rest of abdomen maroon-brown with a plenitude of clear pale roundish spots; second abdominal segment with two parallel dark-brown lines along posterior margin. Antennae long, pale orange except proximal half of first segment and whole of last, which are infuscated. Legs infuscated, but pale at joints, distal two-thirds of tibia. and first tarsal segment; fore-femora very thick. Under-surface with region of gula and of coxae whitish, rest of head and thorax black except edge of latter; abdomen brownish, mesally pale-yellowish and laterally very dark with pale spots as on dorsum. Rostrum pale with black terminal segment, reaching intermediate coxae. Length, 2·83 mm.

Late Instar (Plate 82, fig. 5).—Head, antennae, and pronotum as in previous instar; mesonotum with two triangular pale spots on fore-border continuous with those on hind-border of pronotum, and outside these two yellow vittae commencing on fore-border and converging caudad almost to meet on hind-margin; outside these again two longitudinal vittae and finally two further ones confluent with the thin pale outer edging of the pads; hemielytral pads with pale-yellow vitta on inner (dorsal) edge; metanotum as far as visible resembling that of intermediate instar; abdomen with scent-glands areas relatively larger.

Fore-femora very stout, pale at base, then piceous, and finally pale red distally; second femora similar in colour but very much thinner; rostrum barely reaching intermediate coxae. Length, 3·41 mm.

Seasonal Occurrence.

The dominant instar at Auckland in February was the fifth. At this time adults and fourth-instar nymphs were not uncommon, while a few third instars were seen. Imagines have occurred in August, September, February, March, May, June, and July. Those found in May and July

were hibernating at the bases of *Juncus effusus* L., in company with nymphal ticks (*Haemaphysalis bispinosa* Neumann); many more of the bugs being present in the later month. In June wintering adults were found in the crowns of strawberry-plants, while in August they were plentiful in the tightly rolled dead leaves of *Phormium tenax* Forst.—a very secure shelter.

Host Plants.

This species is nearly always about low herbage or on the ground itself, although the Kermadec record is from *Coprosma* sp. (W. L. Wallace). The writer has collected it on strawberry (*Fragaria vesca* L.), *Phormium tenax*, *Juncus effusus*, and especially the early stages in great numbers on a dense dark-green sward of *Juncus lampocarpus* Ehr. interspersed with *Sparganium subglobosum* Morong, a species of *Cyperus*, and *Lotus major* Sm., *Bulbilis dactyloides* (Nutt.) Raf., and *Polygonum persicaria* L. It would be difficult to discover whether it was restricted to any one plant in this association.

Distribution.

Hutton (1898B, p. 174) gives the habitat as Auckland. Kirkaldy (1909B, p. 26) writes, "also recorded from the Hawaiian Islands, Tahiti, and the Philippines. The synonymy of this species is perhaps a little doubtful. I have recorded the var. *inornata* (Walker) from Chatham Islands." The writer has seen specimens collected at the Kermadec Islands (on Sunday Island) by Mr. W. L. Wallace.

So far as the New Zealand mainland is concerned, it is apparently confined to the North Island, in which again it is abundant only in the northern portions. In the North Auckland Peninsula and in the vicinity of Auckland City it is plentiful, but outside these limits it has occurred only at Greytown and Wellington (one straggler floating on a pool of water).

Writing of Hawaiian conditions, Kirkcaldy (1907A, p. 246) remarks, "F. B. White, on Blackburn's authority, states that this species does not occur below about 1,000 ft. above sea-level, but that was probably a mistake then, and certainly is so now, as it comes at night to light in houses from sea-level upwards."

Targarema stali F. B. W.

Seasonal Occurrence.

Adults have occurred in November to March inclusive, with an overwhelming maximum of abundance in January, during which month pairing has been observed (I. H. Myers).

Host Plants.

T. stali may be beaten from a number of shrubs in the undergrowth of the forest. Specifically, it has been taken on *Leucopogon fasciculatum* (Forst. f.) Diels, on *Nothofagus Solanderi* (Hook. f.) Oerst, and in great abundance on the flowers of *Weinmannia racemosa* L.

One pale, soft, recently-emerged specimen taken at Ohakune in leaf-mould may indicate this material as the nidus of the immature stages.

Distribution.

Hutton (1898B, p. 174) mentions the range as Auckland. The writer's material has come from Whangarei, Ohakune (T. R. Harris, 2,100 ft.), and the Wellington district; so that it is probably generally distributed throughout the North Island.

Miscellaneous Note.

"*Targarema* sp. nov." in the Hutton collection at Canterbury Museum is a Mirid.

Margareta dominica F. B. W. (Plate 82, fig. 6.)

An Intermediate Instar (Plate 82, fig. 6).—Head and thoracic nota blackish-brown, rather hairy; a very narrow pale line along middle of nota; abdomen brick-red slightly brownish basally; three almost equal scent-gland areas each divided into two by white lines parallel with or equivalent to segmental margins; antennae brownish, darker distally; legs brownish, femora darker; rostrum infuscated at tip, almost reaching middle of abdomen; abdomen beneath brick-red with a blackish patch towards apex. Length 2·95 mm.

Seasonal Occurrence.

All stages of nymphs have occurred on the food-plant in January. Adults have been collected from December to February inclusive. There is probably only one brood per year.

Host Plants.

The whole life-history appears to be passed on *Gahnia*, usually and possibly solely on *G. xanthocarpa* Hook. f., from the shining dark-brown fruits of which it is extremely difficult to distinguish the bugs when seeds and insects fall together into the net.

Distribution.

Hutton (1898B, p. 174) gives the range as Auckland. I have seen specimens from Auckland (C. E. Clarke), Tararua Range, and the Wellington district (T. Cockcroft, J. G. Myers). On the Tararua Range it ascends to 4,500 ft. and 5,000 ft.

Taphropeltus putoni (F. B. W.) Bergroth (= Scolopostethus F. B. W.).

Seasonal Occurrence.

Only the adult has been collected, and this in August, and from October to March inclusive, and in May. It has been found wintering at the bases of *Juncus effusus* L. and *Bromus unioloides* H. B. K. It is most plentiful at midsummer, but is not collected in large numbers.

Host Plants.

Fuchsia excorticata (Forst.) L., *Juncus effusus*, and *Bromus unioloides* have yielded this species. It occurs in sweeping mixed herbage and undergrowth, but never plentifully.

Distribution.

Hutton (1898B, p. 175) gives the habitat as Auckland. It is probably generally distributed throughout the North Island, as I have examined material from North Auckland (Kaitaia), Ohakune (2,100 ft., T. R. Harris), Levin, and the Wellington district.

Cymodema sp.

Seasonal Occurrence.

Adults have been taken in August, December, and February in the sweeping-net, and in May and July in winter quarters at the bases of rush-clumps, where they were most abundant in the later month.

Host Plants.

Meadow-grasses, especially *Bromus unioloides* H. B. K., are favoured. In winter the bases of *Juncus effusus* L. afford them shelter, in company with nymph ticks (*Haemaphysalis bispinosa*) and other hibernating Arthropods.

Distribution.

This undescribed species, for the generic location of which I am indebted to Dr. Bergroth, has been collected in North Auckland (Kaitaia), Wanganui, Levin (Weraroa), and Waikanae.

Family 15 (35). Neididae.

Neides wakefieldi F. B. W.

Seasonal Occurrence.

This by no means abundant species has been taken in December and April. I have seen only adults.

Host Plants.

The writer beat a single specimen from masses of creeper on the edge of a clearing in kahikatea forest at Wanganui (Long-acre). Mr. J. F. Tapley took numerous examples by sweeping grasses and other herbage.

Distribution.

Hutton (1898B, p. 172) gives Wellington as the locality. My specimens came from Wanganui, and from Governor's Bay, Canterbury (J. F. Tapley). It seems to be very rare in the North Island.

Miscellaneous Notes.

Buchanan White (1878, p. 31) writes: "It is very probable that this is an apterous form of a dimorphic species—dimorphism being not infrequent in this family, though the species are rarely so brachypterous as in this instance." It should be noticed that Buchanan White's term "apterous" is incorrect as applied to this species, of which all individuals save one examined by me, in both sexes, possess short hemielytra—extending, it is true, only a third of their own length past the base of the abdomen. The

single specimen exhibiting a different condition has well-developed hemielytra extending past half the length of the abdomen, and hind-wings reaching about half-way down the abdomen. The hemielytra in this case are less punctate than in the brachypterous form. This condition is only relatively macropterous, since flight would be quite impossible. There can be no doubt that brachyptery is the normal condition.

Family 16 (37). PYRRHOCORIDAE.

The single species of the family, *Dindymus versicolor* H. S., recorded from this country by Kirkaldy (1909B, p. 29), has probably not become established. So far as the present writer knows, Kirkaldy's single specimen of this common Australian bug is the only one known from New Zealand.

Family 17 (39). ARADIDAE.

The very numerous representation of this family both in species and in individuals in this country has been noticed in the general account. These bugs are said to subsist on fungi, but their feeding-habits have not yet been definitely ascertained.

Aradus australis Erichs.

Seasonal Occurrence.

Only adults have been collected, and these all in February, except for three occurrences in November, December, and January. February appears to be a flying-period, during which the bugs may be found in the most unlikely places—in houses, on windows in cities, and often in large numbers in spiders' webs.

Distribution.

Hutton (1898B, p. 175) states that it occurs in Otago and Canterbury. I have specimens from Pokaka (D. Miller), Ohakune (2,100 ft., T. R. Harris), Paraparaumu, and Wellington.

Kirkaldy (1909B, p. 25) writes, "also from Australia, Tasmania, and New Caledonia. I have recorded it from Chatham Islands."

Ctenoneurus hochstetteri (Mayr). (Plate 83, fig. 1.)

I have elsewhere given a brief account of the life-history of this abundant species (Myers, 1921A, pp. 235–37, figs. 1–5 and pl. 44). For details reference must be made to this paper.

The egg is 1½ mm. long, elliptical, and pure-white, the surface hexagonally punctate. "The ova are deposited promiscuously or in patches on the bark or portions of the trunk, and are gummed lightly by the long axis of the eggs." At hatching the chorion splits along two-thirds of one side to the end, with one or two transverse fissures not extending more than half-way round the egg.

"The first instar (Plate 83, fig. 1) is white or colourless except for a yellow scent-gland area. The second instar shows little structural change; but colour appears as a dark grey on the head" and as grey markings on the dorsum.

"The subsequent nymphal history is marked by an enormous increase in the size of the body relatively to the length of the appendages; by the appearance of spines on the lateral margins of the head; by the growth of tubercles and spots on the posterior margins of the abdominal segments; by the increase of granulation over the whole dorsal surface; and, above all, by the gradual curving of the mesonotal and metanotal posterior margins with the formation of wing-pads. . . The compound eyes of the second and subsequent instars are brilliant red."

There are indications that *C. hochstetteri* passes through more than five stadia, but this needs further investigation.

Seasonal Occurrence.

Eggs and all stages of nymphs have occurred in September, intermediate ones in April, and fairly advanced nymphs in June and July. Eggs have hatched as late as April. Adults have been collected in June, July, September, October, December, January, and April. In 1921 I wrote, "Individuals of most instars are found throughout the season." There is thus an indication that breeding goes on throughout the year, not greatly affected by seasonal change.

Host Plants and Habitat.

This, our commonest Aradid, is found most often under the bark of dead trees, including *Beilschmiedia tawa* (A. Cunn.) Benth. and Hook. f., *Weinmannia racemosa* L., and the introduced *Ulmus campestris* Smith and *Eucalyptus globulus* Labill. Probably any loose bark is suitable.

Distribution.

Hutton (1898B, p. 175) gives the locality as Auckland. My specimens were taken at Kaitaia, Wanganui, Levin (Weraroa), Tararua Range, and the Wellington district, in the North Island; and at Mount Arthur (T. Cockcroft), Blenheim (W. Purdie), and Governor's Bay (J. F. Tapley), in the South.

Miscellaneous Notes.

The abundance of this species, especially under tawa-bark, is often phenomenal, and their odour most pronounced. They are said by bushmen to bite like bed-bugs (*Cimex*).

In December, in North Auckland, a few individuals were found flying at midday in hot sunlight. This seems to point to a wandering period similar to that of *Aradus australis*, though the migrations are probably not so extensive.

It may be of interest to note that imagines of *C. hochstetteri* are sometimes found carrying several first- or second-instar nymphs on their backs and sides. Considering the gregarious habit of the species, perhaps we should rule out maternal solicitude as an explanation; but it is significant that these young nymphs apparently do not cling to older nymphs which closely approach imagines in size.

Walker (1868, p. 137) described a specimen of the common large black Blaltid, *Platyzosteria novae-zealandiae* (Brunner) (= *Periplaneta fortipes* Walker), as feeding on bugs under the bark of trees. The bugs mentioned would probably be *Ctenoneurus hochstetteri*.

Aneurus brouni (F. B. W.). (Plate 83, figs. 2–5, and text-fig. 9.)

Eggs. (Text-fig. 9.)

The eggs are somewhat elliptical, with three chorionic projections at the micropylar end and apparently no sculpture. They thus differ much from the sculptured but simply elliptical ova of *C. hochstetteri*. They are pure-white. Length, 1·1 mm.

Nymphs.

Second Instar (Plate 83, fig. 2).—Cream-coloured with brownish areas of higher chitinization; these sclerites are distributed as shown in the figure; last joint of antennae infuscated; eyes red; scent-gland, which is apparently single, showing red through the thin dorsal cuticle; general shape long oval, broadest posteriorly. Length, 2·0 mm.

Third Instar (Plate 83, fig. 3).—Like second except that the head is more acutely angulate and the appendages relatively smaller; a slight curving of the mesothorax caudal margin is discernible. Length, 2·8 mm.

Fourth Instar (Plate 83, fig. 4).—Mesonotum greatly enlarged. Length, 3·3 mm.

Fifth Instar (Plate 83, fig. 5).—Great development of wing (hemielytral) pads. Length, 3·9 mm.

Seasonal Occurrence.

Eggs and practically all nymphal instars, together with adults, were found in July. Imagines have been collected also in the months from November to January inclusive.

Distribution.

This is not a common species. It affects the same subcortical habitat as *C. hochstetteri*.

Hutton (1898B, p. 176) records it from Auckland. The writer has specimens from Ohakune (2,100 ft., T. R. Harris) and Wellington district (T. Cockcroft, J. G. M.) in the North Island; and from Mount Arthur (T. Cockcroft, elevation not noted) in the South.

Family (40). SCUTELLERIDAE.

The records of New Zealand specimens of the Australian bugs *Calliphora imperialis* (Fabr.) and *Scutiphora pedicellata* Kirby are probably incorrect. If not, then nothing more than the merest stragglers could have been taken here, since neither species is established, nor has either been collected in New Zealand since. The supposed Scutellerine nymph recorded by Kirkaldy (quoted by Alfken, 1904, p. 583) is undoubtedly one of the instars of *Zangis amyoti*.

Family 18 (41). PENTATOMIDAE.

The Australian species *Diemenia immarginata* (Dall) and *Poecilometis gravis* (Fabr.), and the European *Sciocoris helferi* Fieber, have been recorded from New Zealand, almost undoubtedly in error. *Nezara viridula* is also very doubtful as a New Zealand species. Including the recently

discovered brachypterous species, there are thus only eight Pentatomidae occurring in the Maorian region—a truly remarkable paucity.

Hart (1919, p. 158), writing of North American forms, states that most bugs of this family are single-brooded, and many hibernate as adults. This applies also to the New Zealand species so far as known.

Butler (1923) and Reuter (1912) seem to imply that all the eggs of this family are operculate. In the New Zealand species there is, however, a sharp distinction between the eggs of Pentatominae and Asopinae on the one hand and those of the Acanthosomatinae on the other. The latter are beyond comparison simpler, usually spheroidal, pale-coloured, with non-pigmented, practically unsculptured chorion and no operculum: hatching takes place by a more or less even splitting of the chorion, and there is no egg-burster. In all these respects the ova of the two Acanthosomatines, *Rhopalimorpha* and *Oncacontias*, are much alike. Such a relatively unspecialized egg agrees well with the theory that the subfamily in question is primitive.

The eggs of the other two subfamilies mentioned, as exemplified by the species *Zangis amyoti*, *Dictyotus caenosus* and *Cermatulus nasalis*, bristle, however, with specializations. The chorion may be brilliantly coloured and heavily sculptured, an operculum is present, often surrounded by pedicellate chorionic processes, varying in number with the species, and for forcing up the operculum at hatching a membranous appendage within the egg is provided distally with a heavily chitinized T-shaped or anchor-shaped egg-burster. In structure generally the ovum of *Dictyotus* stands intermediate between that of *Zangis* and *Nezara* on the one hand and that of *Cermatulus* and *Oechalia*—the two Asopines—on the other.

The nymphs of New Zealand Pentatomidae are sufficiently like their parents, and the species are so few, that specific identification of immature instars should be easy. The only ones which can possibly be confused are those of *Cermatulus nasalis* and *Zangis amyoti* in the very early stages, and to a less extent in the later. Always, however, the stout carnivorous Asopine beak of the former will distinguish it at a glance.

Oechalia consocialis (Boisd.).

Life-history.

Nothing is known under New Zealand conditions. In Australia Froggatt (1907, p. 330) writes: "They lay their rounded glassy eggs in patches of about a dozen on the foliage, and the freshly emerged bug is dark brown and flattened in form. The adult bug varies very much in size." Kirkaldy (1907B, pp. 141–42, fig. 1) has described and figured the egg of the closely related *Oechalia grisea* (Burm.) in Hawaii. It bears a considerable resemblance to that of *Cermatulus nasalis*, described below, but is more rounded, has "a circular row of about fourteen short black teeth on the *operculum*," and the sides "reticulated with granules."

Seasonal Occurrence.

This species is very rare in New Zealand. The writer has seen four specimens, one taken in October, two in March, and one in April.

* Two specimens of a new black brachypterous Pentatomid were taken by Miss Stella Hudson in alpine meadow, at about 3,500 ft., on the slopes of Mount Aurum, near Lake Wakatipu, in January, 1921. They are being described by Dr. Bergroth.

Host Plants and Feeding-habits.

"In Australia, *Oechalia* is (at least partly) carnivorous, preying on the larvae of *Phalaenides glycine* (the vine-moth) and of *Galerucella semipullata* (the fig-leaf beetle)" (Kirkaldy, 1909B, p. 24). It has been taken in New Zealand on pear and *Rubus fruticosus* L. (blackberry). A specimen from the latter was placed in a tube for some days with three live vine-hoppers, *Scolypopa australis* (Walk.), but of these insects it took no notice at all. On one occasion it ejected with considerable force a mass of foamy yellow excreta, which formed a circular patch, 3 mm. across, on the side of the tube about ½ cm. away. Froggatt (1907, p. 330) states that it feeds on several species of cutworms. Kirkaldy (1909A, p. 82) states that it is carnivorous. He proceeds to quote Bergroth to the effect that it "se nourrit des cadavres de divers animaux." Mr. Cockcroft found two adults on plants of *Cosmos* sp. in a garden at Hamilton.

Distribution.

Hutton records it from Auckland (1898B, p. 109). My records are Auckland (D. Miller), Hamilton (T. Cockcroft), Wairoa, H.B. (J. G. Myers), and Nelson (A. Philpott).

"The record from the Philippines is almost certainly a mistake" (Kirkaldy, 1909B, p. 24). Its headquarters are evidently Australia and Tasmania.

Cermatulus nasalis (Westwood). (Plate 83, figs. 6, 7; Plate 84, fig. 1; and text-figs. 10–13.)

Eggs.

On the 3rd November, 1922, just at the lower edge of beech (*Nothofagus*) forest, eggs were found on the under-surface of a single blade of a tall culm of sweet vernal (*Anthoxanthum odoratum* L.), which was bearing an inflorescence still green through growing in the shade of the beeches, and which carried below the attachment of its single leaf about twenty-two egg-nests of the common cicada, *Melampsalta cruentata* (Fabr.), crammed with ova. The leaf was horizontal, and the *Cermatulus* eggs were arranged in three rows, a little nearer base of leaf than apex, and all parallel with the long axis of the blade. In one row were fifteen eggs, in the next sixteen arranged alternately to those of the contiguous first row, and three only in the third row, closely applied to the second near its end. The batch thus contained thirty-four eggs, all of which appeared to be solidly glued to the support and to the adjacent eggs, both of their own row and of the next rows.

A second batch was deposited on the leaf of a fruit-tree at Pukekohe, and contained a dozen eggs in a compact group. A third cluster which I refer to this species, and which came from the neighbourhood of Christchurch, consisted of two close rows on a slender twig, with about ten ova in each row.

The shape of the egg is oblong or cylindrical, with parallel sides and flattish rounded ends. At the edge, where the perpendicular sides merge into the top, or operculum, is a circle of black spinous chorionic processes; twelve or fourteen in number, arranged at more or less regular intervals. Each process bears a thin inwardly-arching pure-white opaque pedicel, carrying at its extremity a rounded or pear-shaped knob of similar whiteness

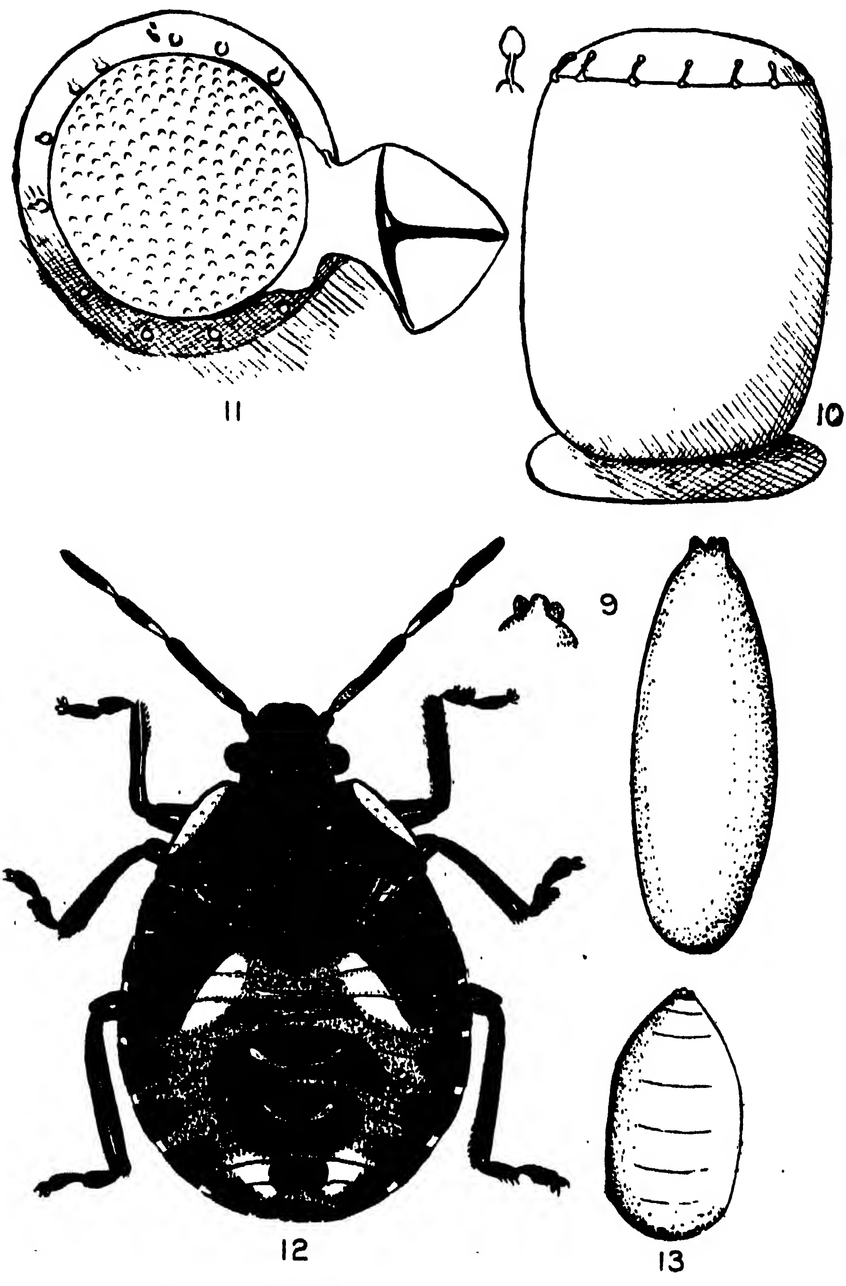


FIG. 9.—*Ctenoneurus brouni* : egg.
FIGS. 10–13.—*Cermatulus nasalis* : 10, eggs, enlarged ; 11, egg-shell, showing egg-burster ; 12, fifth instar ; 13, puparium of dipterous ? parasite.

and opacity. In many the pear-shaped end, or even the whole pedicel, had been broken off. Often a whole circle is damaged or broken.

Height of egg, 1·3 mm.; diameter of operculum, 1 mm.

The colour is a pure and beautiful metallic gold. The surface is covered with a very faint hexagonal reticulation.

Hatching: The operculum usually remains covering the opening of the empty egg-shell, and the egg-burster protrudes from beneath its edge.

Nymphs.

First Instar.—The general appearance is black with two bright-yellow spots. Head, thorax, legs, antennae, most of connexivum, odoriferous orifices all shining-black; terminal portions of all antennal segments pale-reddish: abdomen dark-reddish, almost black to the naked eye; a bright-yellow spot extending on each side of first odoriferous orifice and occupying the length (cephalo-caudally) of at least two segments; two similar but very indistinct and paler spots at extremity of abdomen.

Fifth Instar.—Considerably longer than broad, coppery black relieved with cream-coloured spots and marks. Head completely black; thoracic nota black with narrow edging of cream; base of abdomen, between wing-pads and scutellum, cream, forming thus two conspicuous cream-coloured spots about middle of body; dorsum of abdomen occupied chiefly by a considerable swelling spot of black containing odoriferous orifices; on each side of this are cream-coloured areas speckled with black and extending to black edges, where connexivum exhibits a wide crescent of cream-colour in each segment forming an interrupted continuation of cream edging of thoracic nota. Under-surface blackish-red; whitish between coxae; rostrum almost black, but distal half, except actual tip, somewhat paler than the rest; antennae very characteristically marked—first segment short and black, second pale red with black tip, third with proximal half pale red and distal half black, fourth black except a very small pale-red portion at base. Tibiae with a wide band of white near middle (narrower in first pair of legs); remainder of leg black.

In a slightly smaller specimen, evidently belonging, however, to the same instar, the areas mentioned above on each side of odoriferous openings are not wholly cream-coloured, but blackish except caudally, where there is a cream-coloured spot on each.

Life-history.

1. Eggs found, 3rd December, 1922; hatched, 16th December; first ecdysis, 27th December.

2. Eggs found, 19th November, 1923; hatched, 24th November; first ecdysis, 2nd December.

3. Fifth instar found, 17th December, 1923; last ecdysis, 5th January, 1924.

On hatching, the young clustered together in a close body on the opposite side of the leaf to the egg-mass. Later they grouped themselves together on the stalk. They seemed never to feed. The second instars, as soon as they hatched, crawled about actively, but were killed later, probably by the cold weather at Arthur's Pass, whither the writer had travelled. Perhaps under the influence of cold they had begun to cluster like the first instars, but could always be stirred to swarming activity, like larval ticks, by the warmth of one's hand.

At the last ecdysis the notal split does not extend to posterior border of mesonotum, whereas in *Zangis amyoti* it includes the whole of the metanotum as well.

Seasonal Occurrence.

Eggs have been found in November and early December, first instar in January (South Island), second instars in December and January, third instars in December, fourth instars in January and March, fifth from December to March, and adults from August to March and in May.

In the last month mentioned, Mr. T. Cockcroft found an adult under a log, in which situation it was probably hibernating. The indications are that *Cermatulus nasalis* passes the winter as an adult, and that it produced one brood per year, like many other Pentatomidae whose life-history is more fully known.

Host Plants and Feeding-habits.

Plants function chiefly as shelter and hunting-ground for this typical carnivorous species. Hutton (1898B, p. 170) mentions that it occurs "generally on trees." The writer has taken it from the following plants: *Muehlenbeckia australis*, mixed undergrowth of *Nothofagus* forest, *Carex* sp., *Anthoxanthum odoratum* L., and flowers of *Metrosideros scandens* (white rata).

As with many predaceous insects, specimens are usually few and far between. On one occasion, however, the writer found the fifth instar very plentiful on *Muehlenbeckia australis* heavily infested with the Ricaniid *Scolypopa australis* and an unnamed large green Bythoscopid. The abundance of these Homoptera, which, especially in their nymphal stadia, probably formed the food of *Cermatulus*, was to be gauged by the fact that the foliage was black with fungus growing on the honeydew secreted by these hoppers.

In captivity the older instars throve amazingly on a diet of "pear-slug"—the larva of the pear and cherry saw-fly (*Eriocampoides limacina* (de Geer)). Broun (1896, p. 9) has seen the same larvae attacked in nature; the rostrum of the bug, according to this observer, being often thrust through the leaf into the "slug" from below. The caterpillars of the following Noctuid moths are devoured: *Agrotis ypsilon* Rott., *Cirphis unipuncta* Haw., *Heliothis obsoleta* (Fabr.), and *Persectania composita* (Guen.). Their pupae may also be destroyed. A large larva may be sucked, but not emptied till a second meal some hours afterwards. Even the common cicada, *Melampsalta cruentata* (Fabr.), has been known to fall a victim to the adult *Cermatulus* (see Myers, 1921B, p. 240). That such powerful and wary prey can be mastered indicates a high degree of skill in the bug's method of attack.

The food of the early instars is unknown. A first or second instar remained alive and apparently healthy for six days in a closed tube with nothing but a few leaves of *Coprosma rhamnoides* A. Cunn. At the end of the period, moreover, its abdomen looked quite swollen as though with food, so it may have taken to a vegetable diet—although, of course, the first instar in the normal course of events rarely feeds. Finally some sow-thistle covered with aphides was introduced. Over this the bug crawled energetically, plying its antennae vigorously, and often stopping to tap the surface of the leaf with these organs. The rostrum meanwhile, often held in a porrect position, kept up an incessant dabbing motion. Frequently it stopped and drew its antennae very deliberately through the basal portions of the apposed fore-tarsi. Occasionally the rostrum was cleaned

in precisely the same way. No notice was taken of the aphides, but the honeydew with which these insects bespattered all surroundings may have been tasted. In two days the bug was dead, apparently entangled in the now sticky leaves.

Kirkaldy (1909A, p. 82) writes: "I have . . . recently received some nymphs of . . . *Cermatulus nasalis* with caterpillars of *Asaphodes megaspilata* (on *Leptospermum scoparium*) attached to their beaks. from my friend Mr. George Howes, of Wellington."

That the species may turn occasionally to a vegetable diet is indicated by the following observations of Hudson (1892, p. 121, pl. 20, fig. 6, imago; fig. 6*a*, "larva"): "This insect may be beaten out of various trees during the summer, and is usually taken in some abundance in February amongst white-rata blossoms, on which it may be often observed sucking the honey from the blossoms with its long rostrum. Its larva, which is represented at fig. 6*a*, is found in similar situations." I myself have taken this bug on the flowers of white rata (*Metrosideros scandens*) in February, so these are evidently a favourite resort.

The bug appears to be partially nocturnal in its habits.

Distribution.

As might be expected, this bug has a wider range of habitats than the strictly phytophagous species. It is frequently found on either cultivated ground or forested country.

The altitudinal range is from sea-level to at least 3,000 ft. (Arthur's Pass). North Island localities extend from Rangitoto Island and Pukekohe, near Auckland, in the north, southward to Lake Taupo (E. H. Atkinson !), Ohakune (T. R. Harris !), Makatote (D. Miller !), Raglan (Miss E. M. Parker !), Wanganui River, Wanganui, Manawatu (D. Miller !), Waikanae, and Wellington. In the South Island it occurs at Blenheim (C. Craigie !), French Pass and Stephen Island (Kirkaldy), at Jackson's and Greymouth on the west coast (S. and C. Lindsay, T. Cockcroft !), on both sides of Arthur's Pass and at Little River (T. Lee !), and finally at the Port Hills (Christchurch) (E. S. Gourlay !). Hutton (1898, p. 170) gives the range as "Auckland to Otago" The species is plentiful also in Australia and Tasmania.

Miscellaneous Notes.

Cermatulus nasalis is probably the most beneficial member of the order Hemiptera in New Zealand. Its extensive menu includes several important pests of agriculture, notably the various cutworms and army-worms.

A specimen was seen in May flying in hot sunshine with a loud humming like that of a humble-bee.

The half-grown nymph, with its dark coloration relieved by conspicuous pale spots, is often mistaken for a ladybird.

Miss Janet Anson brought me a supposed egg of this species. The object, which had appeared in a box containing nothing but a specimen of the bug (sex not ascertained), is shown in text-fig. 13. It is apparently the puparium of a dipterous parasite, but although I kept it for several years nothing emerged from it. Possibly also parasitized was a specimen of the bug sent me from Ohakune by Mr. T. R. Harris in 1923, with a neat almost circular hole bored in the under-surface of the abdomen near the tip, and about 1·3 mm. in diameter. This hole may, however, have been the work of museum pests since the insect was pinned.

Zangis amyoti (Dallas). (Plate 84, fig. 2; Plate 85, figs. 1–3; and text-figs. 14–17.)

Eggs. (Plate 84, fig. 2; and text-figs. 14, 15.)

Eggs found on leaves of *Coprosma robusta* Raoul in the Hokianga in December were buffish in colour, changing to dull orange in a few days. One patch contained fourteen eggs, arranged irregularly, but all touching, on the upper surface of a leaf near the tip. A second lot contained also fourteen eggs, arranged rather more regularly near the base of a small leaf. A third batch of fourteen was deposited fairly regularly near the base of a large leaf. All three lots were on the upper surface of their respective leaves, and were not hard to discover. Other eggs, from Auckland and from Dargaville, were deposited on the upper surface of *Pittosporum* leaves, probably *P. Colensoi* Hook. f.

The empty shells are pale buff, with uniform but not very pronounced pitting. Dimensions, 1·5 mm. by 1·4 mm. Shape as indicated in Plate 84, fig. 2, much more rounded than in *Nezara.* Judging by the way they adhere to one another when detached with no great force from the leaf, they are stuck together very firmly.

On hatching, the egg-burster remains just within the opening of the empty shell, and the operculum frequently becomes completely detached and lost.

Nymphs.

First Instar (Plate 85, fig. 1; and text-fig. 16).—Length, 2·0 mm. As broad as long (practically circular), shining jet-black above and below except a white spot on each side at base of abdomen; segments of antennae slightly paler towards their tips.

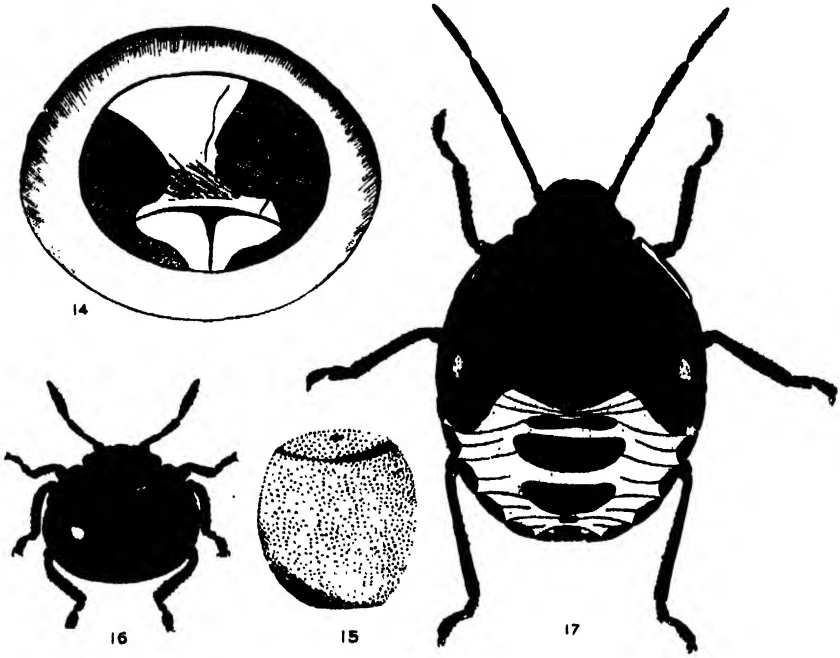
Second Instar (Plate 85, fig. 2).—Length, 3·1 mm. Rather longer than broad; jet-black; the two white spots of previous instar unaltered, but in addition a whiter spot at base of abdomen, but in a much more lateral position on each side (actually, in fact, on the connexivum), simulating exactly a constriction or waist. Only very close examination reveals that these are really spots.

Third Instar (Plate 85, fig. 3).—Length, 4·0 mm. Head almost entirely orange-brown, with black eyes and an area on caudal border and a narrow edging to remainder of head also black; two faint orange-brown spots on each side of thoracic nota—one on pronotum and other on mesonotum—rest of nota greenish-black, the connexivum green; abdomen pure rich green; odoriferous areas shining black; a large bright-yellow spot on each side of base of abdomen; connexivum with six black plaques or semicircles ("lateral plates" of Hart) in relief, on each side, corresponding to first six visible segments of abdomen. Ventral surface pale-greenish; coxae, femora, underside of head, sterna greenish-yellow; rostrum yellowish-amber with black setae and terminal segment; tibiae and tarsi brownish-black; antennae wholly brownish-black; whole under-surface very narrowly edged with black.

Fourth Instar.—Head, thorax, antennae, and legs almost wholly shining jet-black; abdomen with scent-gland areas and semicircular plaques ("lateral plates") on connexivum in each segment jet-black, remainder blackish except a bright-yellow spot on each side of basal segment, connected by narrow yellow line; a very narrow greenish line of division between scent-gland areas. The two yellow basal spots may form a wide

continuous band. Under-surface of head, thorax, a narrow edging and median longitudinal line of abdomen black; rest of abdomen pale-greenish (underside).

Fifth Instar.—Length, 10·0 mm. Head, thorax, antennae, and legs greenish-blackish-bronze, with a slightly paler area (brownish tinge) on each side of thorax; scutellum darker; abdomen bright yellowish-green; the three scent-gland areas shining greenish-black, separated from scutellum in front and from one another by narrow areas of bright canary-yellow



Figs. 14–17.—*Zangis amyoti:* 14, egg-shell, showing egg-burster; 15, eggs further enlarged; 16, first instar; 17, fifth instar.

(the first yellow band wider and much longer than others and extending from one wing-pad to the other); connexivum edged extremely narrowly with black, which widens into an elliptical black mark ("lateral plate") in each of the first six visible segments (first two marks are, however, hidden by wing-pads). Ventral surface pale yellowish-green edged peripherally very narrowly with black.

Life-history.

1. Eggs found, 19th December, 1923; eggs hatched, 20th December; first ecdysis, 29th December; second ecdysis, 14th January, 1924; third ecdysis, 26th–28th January; fourth ecdysis, 8th–10th February.

2. Eggs found, 19th December, 1923; eggs hatched, 24th December; first ecdysis, 4th January, 1924; second ecdysis, 14th January; third ecdysis, 30th January; fourth ecdysis, 12th February.

3. Eggs found, 19th December, 1923; eggs hatched, 24th December; first ecdysis, 4th January, 1924; second ecdysis, 17th January; third ecdysis, 30th January; fourth ecdysis, 11th February; fifth ecdysis, 4th March.

As in so many other Pentatomids, the newly hatched nymphs remain clustered and quiescent near or on the egg-shells. After a few days they may begin to move about a little, but I believe no food is taken in this stadium. In marked contrast to this behaviour, the second instar is very active.

Intrastadial colour-changes are somewhat marked. Thus about half-way through the second stadium, sometimes sooner or sometimes later, the nymphs look appreciably larger, and a bright-yellow spot appears on each side of the base of the abdomen, just mesad and caudad of the white spot which gives the appearance of a waist. Is this the conspicuous spot of the third instar (see description above) showing through the second instar cuticle? Again, in the fourth instar, some nymphs have an entirely pale-green abdomen, except for yellow basal band and black marks on connexivum ("lateral plates") and scent-glands ("dorsal plates" of Hart), while in others it is wholly blackish. The recently emerged fifth instar is almost wholly pale green except for the usual yellow markings and the general yellowish tinge of the abdomen. Even at three days from ecdysis the only really black markings may be confined to an edging on head and thorax, the scent-gland areas (or dorsal plates), and the connexival plaques (lateral plates), the rest of head and thorax being brownish-green. How far this may indicate an actual dimorphism in the nymphs my material was not sufficiently abundant to decide. Dallas (1851, p. 279) mentions a "var. totus griseo-virescens, antennis obscurioribus," but such a colour in a cabinet specimen can be produced by killing it too soon after ecdysis. Buchanan White in the following passage (1878, p. 276) indicates what may be a dimorphic form: "In addition to typical specimens, there are three examples (more or less fuscous brown, with a greenish tint) which seem to be immature individuals of this species." It is possible, of course, that these are just recently emerged imagines, as White suggests, since I have had such specimens dry with a brownish tinge. At ecdysis the split extends medio-longitudinally along the nota, from posterior margin of metanotum to anterior edge of pronotum; thence it extends along posterior border of occiput and between the eyes and head to the front of the eyes. In the earlier instars the split does not quite reach the eyes.

Seasonal Occurrence.

Eggs occur in December and February. Nymphs of all stadia have been taken in December and February. A late instar nymph was collected by Mr. W. G. Howes in March, in which month both fourth and fifth instars have occurred. Adults have been collected from January to March. *Zangis amyoti* therefore probably resembles several other Pentatomids in wintering as an adult and producing one brood per season.

Food Plants and Feeding-habits.

In New Zealand this bug has been beaten from *Nothopanax arboreum* (Forst. f.) Seem. (R. E. Grimmett), *Pittosporum Colensoi* Hook. f., and *Coprosma robusta* Raoul. In captivity all stages throve on ripe and partially ripe berries of *Coprosma robusta*. That it may not be entirely phtyophagous is indicated by the following incidents: One advanced instar nymph was about half emerged from its exuviae when it was attacked by a third (?) instar, pierced in the mesonotum, and almost drained dry. Broun (1896, p. 9) noticed *Z. amyoti* feeding on "pear-slug" (*Eriocampoides*

limacina (de Geer)) in company with and after the same manner as *Cermatulus nasalis* (*q.v.*). On *Coprosma* bushes the berries are evidently the chief attraction, since many more bugs are beaten from female than from male plants.

Distribution.

The present species occurs also in Australia. In New Zealand I have found it very local. Outside the Auckland district, particularly North Auckland, it is extremely rare. In the Auckland district itself, at the height of its season, I have examined heavily-fruiting *Coprosma robusta* bushes with no success, though one adult was taken at light. The North Island localities are Kohukohu (J. G. Myers), Hokianga (R. J. Nisbett), Dargaville (J. Munro), Auckland (Mrs. I. Woodhouse), New Plymouth (W. G. Howes). In the South Island it has been taken at Nelson (R. E. Grimmett) and French Pass (Kirkaldy, 1909B, p. 24), both extremely northerly localities.

I have recorded it from Sunday Island (Kermadecs), where two were found in 1908 by Mr. W. L. Wallace on Denham Beach (Myers, 1921C, p. 257).

Miscellaneous Notes.

At Auckland, in March, a fine specimen flew into a lighted room at night.

A second instar was observed, while on a berry, to jerk itself galvanically from side to side in a most peculiar manner.

It is rather remarkable, considering the damage committed by the closely-related bugs of the genus *Nezara* in many parts of the world, that *Z. amyoti* has not yet been observed to pay any attention to fruit or fruit-trees.

This species is very likely to be confused with *Nezara viridula* (Linn.), if the latter does occur in New Zealand, which the writer very much doubts. Superficially the adults are much alike, but the eggs and intermediate stages are very dissimilar (see *N. viridula*).

Nezara viridula (Linn.).

Under the name of *Rhaphigaster prasinus* Linn., Walker (1867, p. 356) mentions five specimens (*ggggg–kkkkk*) from New Zealand, presented by Colonel Bolton. It seems to the present writer quite possible that Walker confused *Zangis amyoti* with this species. In any case, the above five specimens are the only ones ever recorded from New Zealand, and their re-examination in the British Museum would soon settle the point. Stragglers of such a cosmopolitan species might easily wander as far as New Zealand. Bueno (quoted by Jones, 1918, p. 11) observes that *Nezara viridula* is recorded "from the whole of Europe except the extreme north, Asia, Africa, Malaysia, Australia, New Zealand, South America (at least in the north), Central America, and enters into the United States at the south, being found in Texas and Florida."

Its economic status is that of a serious pest. In the United States cotton, cauliflowers, beans, tomatoes, potatoes, sweet potatoes, and other crops are attacked, especially at the growing-points and the developing fruit (when present) (Jones, 1918). In New South Wales it damages tomatoes, French beans, and potatoes. From an agricultural viewpoint its scarcity or possible non-occurrence in New Zealand is a matter for congratulation.

Although the adult in size and coloration so much resembles *Zangis amyoti*, all the pre-adult stages, including the egg, can be distinguished at a glance. Good illustrations of eggs and nymphs are given by both Jones (1918) and Froggatt (1916). The egg is remarkably parallel-sided, rising directly at right angles with the surface on which it is deposited, while that of *Zangis amyoti* is much more spheroidal.

The first instar has a large pale-yellow area occupying a considerable portion of the thoracic nota, while all succeeding instars are conspicuously marked on thorax and abdomen with *large, rounded, clear-white spots.*

Regarding the imagines, four specimens collected in Barbadoes and kindly given to the writer by Dr. Dayton Stoner show that they may be distinguished without difficulty from *Zangis amyoti* by the narrower apex of the scutellum, by the less glossy surface of the whole dorsum, and by other characters which need not be detailed here.

Dictyotus caenosus (Westwood). (Plate 84, fig. 3; Plate 85, fig. 4; and text-figs. 18–21.)

Eggs. (Plate 84, fig. 3; and text-figs. 18–20.)

A batch of eighteen was deposited on the upper surface of a grass-blade (an introduced species). They adhered firmly both to the leaf and to one another. On discovery, the colour was pale yellowish-green. In the subsequent absence of the writer, Mr. David Miller kindly watched development. He found that the eggs became pale lemon-yellow, which colour finally, just prior to hatching, changed to pink. He noted, moreover, that the little collection of ova hatched at one end first, and not all at once, several days elapsing before the last egg went through the process.

The empty choria were pure-white, the surface irregularly reticulated with fine ridges, giving the whole a frosted appearance. Height, 0·94 mm.; diameter, 0·90 mm. As in *Cermatulus nasalis*, the operculum almost invariably remains, covering the opening as though hinged at one point, and the egg-burster projects from beneath it. Surrounding the operculum but actually arising from the top of the side walls are about thirty-six fine white chorionic processes, very difficult to discern.

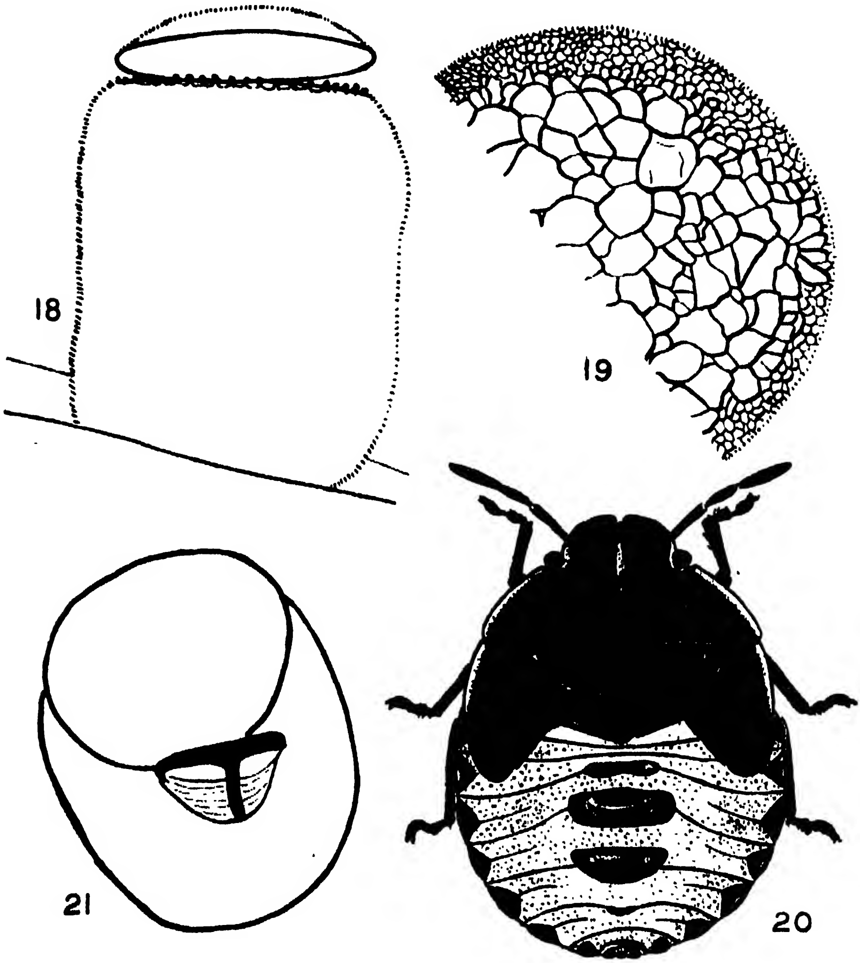
Nymphs.

First Instar (Plate 85, fig. 4.)—Almost circular in outline and dome-shaped in appearance. Head, pro-, meso-, and meta-notum shining blackish-brown; eyes reddish; abdomen yellowish, scarlet laterally, caudally, and between scent-gland areas. First scent-gland area double and very narrow, second and third very large and transverse; lateral plates jet-black; segmental margins scarlet.

Fifth Instar (Text-fig. 21).—Length, 7 mm.; greatest breadth, 4·5 mm.

Head and nota brownish-black with a very narrow white transparent edging, the beginnings of a median longitudinal pale stripe indicated at the base of vertex; antennae black with white articulations; whole of ventral surface of head black; rostrum black with proximal portion of second segment pallid; sternum black except round and between coxae pallid; rostrum reaching just to posterior coxae; abdomen creamy, very thickly freckled with reddish specks, each speck forming the base of a minute blackish granulation, thus giving the effect of blackish-red freckles; the odoriferous orifices jet-black and shining, each surrounded by a black

area—the first a narrow transverse stripe, the second a broad oblong transverse band, the third nearly semicircular, and following these a fourth narrow transverse stripe of black; under-surface of abdomen cream-coloured thickly speckled with reddish like a turkey's egg; a distinct heavy oblong black spot on middle of third and each succeeding ventral



Figs. 18–21.—*Dictyotus caenosus:* 18, egg-shell; 19, structure of operculum; 20, egg-shell, showing egg-burster; 21, fifth instar.

segment to the last, increasing in size caudad; a semicircular black spot occupying lateral margin of every ventral abdominal segment; legs jet-black; tibiae slightly bristly. First segment of antenna less than half second; second one-fifth shorter than fourth; third about two-thirds of second; two-jointed tarsi with second segment longer than first.

Life-history.

Little is yet known. Adults swept from grasses on 14th December deposited a batch of eggs on 27th December; but this period is untrustworthy, since the eggs had meantime been taken to much colder conditions (from Wellington to Arthur's Pass). Hatching commenced on 19th January, after the return to Wellington.

At the last ecdysis the cuticle splits along the whole median longitudinal line of the thorax; side fissures are almost absent.

Seasonal Occurrence.

Ova have been deposited near the end of December. Third-instar nymphs have been collected in January and March, and fifth instar from January to March. Adults occur in October to May inclusive and in July, being especially abundant in March at most localities, but always to be found during autumn and winter in some numbers in hibernation. More were found in hibernation shelters in July than in May. The imago is the wintering stage. Apparently only one brood is produced per year.

Host Plants and Feeding-habits.

Dictyotus caenosus seems to prefer grasses and low herbage generally. It has been swept from English grasses, including cocksfoot (*Dactylis glomerata* L.) and rye-grass (*Lolium perenne* L.), from lucerne (*Medicago sativa* L.), red clover (*Trifolium pratense* L.), and from pastures and roadside grasses. In the course of an investigation of the cattle-tick (*Haemaphysalis bispinosa* Neumann) in New Zealand, this bug was found in large numbers sheltering with the wintering nymph ticks at the bases of the clumps of rushes, or wiwi (*Juncus effusus* L.), which form such a conspicuous feature of the North Auckland and other pastures. Attempts to lead the bugs to eat the nymph ticks, either in the ticks' unfed or engorged condition, met with no success. Most of the nearer relatives of *Dictyotus* are known to be phytophagous, and it is probable that *D. caenosus* is entirely so.

Fifth-instar nymphs have been found plentifully on blackberry-plants (*Rubus fruticosus* L.) (A. S. Wickens). They were reported to be sucking the ripe fruit, especially after it had been picked. Mr. E. O. Hyde states that the adults are a source of constant annoyance to blackberry-pickers in the Nelson district. They swarm over the ripe fruit, and have to be constantly picked out from among the berries in the containers.

This is essentially an insect of open country. We have only one truly forest-dwelling Pentatomid—*Oncacontias vittatus*.

Distribution.

In the North Island it occurs from Kaitaia, in the far north, through Whangarei, Auckland, Raglan (Miss E. M. Parker), Wanganui, to Wellington.

In the South Island it is plentiful in Marlborough and Canterbury (E. S. Gourlay! T. Lee!). Hutton records the species from Auckland to Otago, which is probably correct as far as it goes. It is found also in Australia and Tasmania.

Rhopalimorpha* obscura White. (Plate 85, fig. 5; Plate 86, fig. 1; and text-figs. 22, 23.)

Eggs. (Text-fig. 22.)

A batch of five eggs was laid in a single straight row on the upper surface of the midrib of a *Carex* blade. These were obtained away from the laboratory under conditions that rendered only a pocket-lens examination possible: this showed the eggs to be apparently devoid of sculpture and of markings. Later scrutiny of the empty choria brought to light an extremely faint irregularly-hexagonal reticulation over the entire surface. The shape was spheroidal and the colour greenish, so that the ovum bears a close resemblance to that of the related *Oncacontias vittatus*. The surface appeared remarkably glossy. In six days two red eye-spots were conspicuous on each egg. At hatching the chorion split almost in two, and the halves immediately twisted into rolls. The empty chorion was colourless and transparent.

A second batch was laid in captivity on the under-surface of a cocksfoot (*Dactylis glomerata*) blade between midrib and edge.

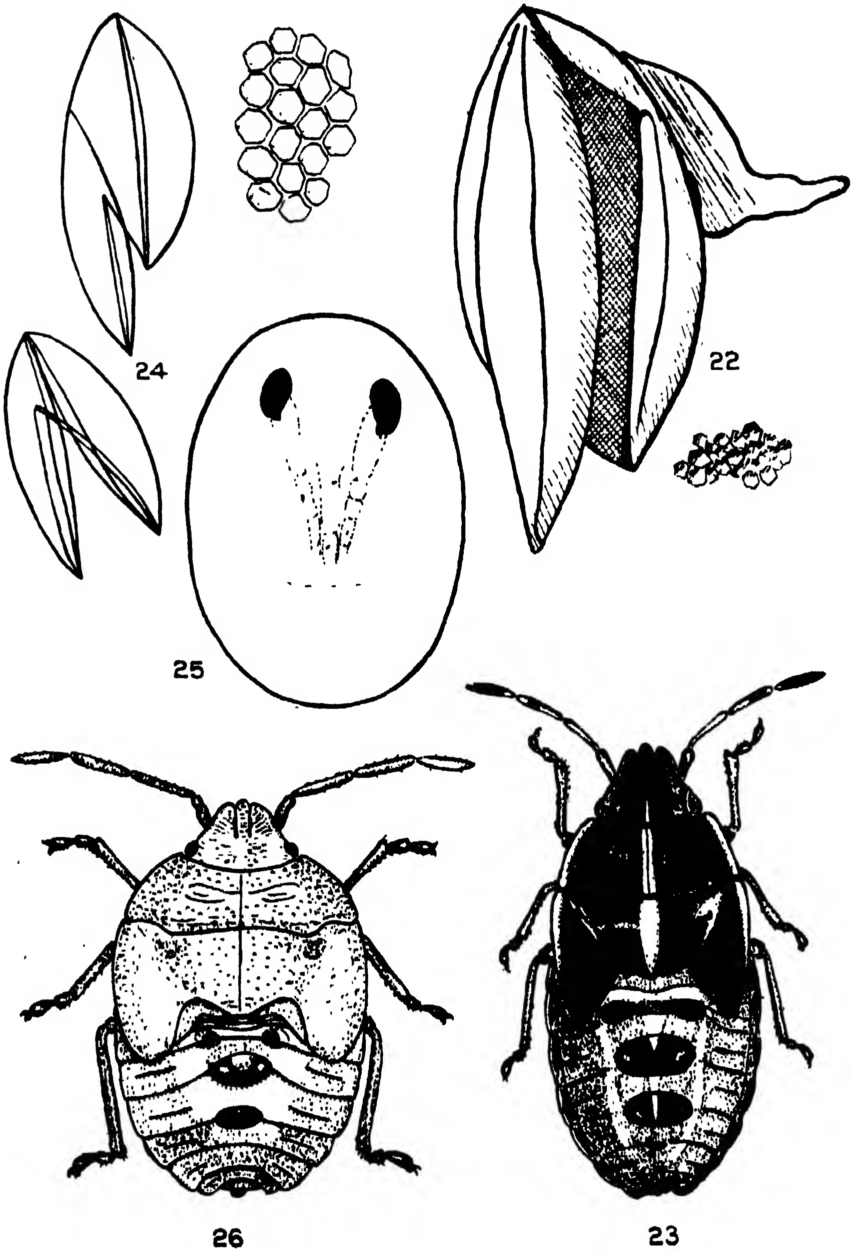
Nymphs.

First Instar.—Almost circular, with dorsum very strongly arched, so that the insect approaches a hemisphere in shape. Head and thorax (forming anterior half of bug) shining black; abdomen pale translucent yellowish-red with three black scent-gland areas surrounded by blackish brown and then by red, except laterally, where these areas are edged with white; a white spot on vertex is in line with a white median longitudinal stripe commencing as a spot on thorax and extending as a narrow line to caudal extremity of abdomen, but interrupted by scent-gland patches of black; appendages almost transparent greenish-yellow.

Second Instar (Plate 85, fig. 5).—Not quite so rounded as first; with very long conspicuous antennae. Head entirely shining black or very dark brown with no pale spot; eyes purplish-red; thoracic nota shining black with yellowish-white median longitudinal stripe commencing at fore-border and extending to cephalic edge of second scent-gland area (first scent-gland area is double and the stripe passes between the two halves); abdomen vivid pinkish-red; the second scent-gland area is double almost like the first; third is transversely elliptical; all scent-gland areas black narrowly edged with white especially laterally; connexivum wholly pale, semi-transparent; appendages transparent yellowish with darker extremities; antennae with the large terminal segment nearly black. Ventral surface nearly black on the thorax and reddish on the abdomen, darker caudally.

Third Instar (Plate 86, fig. 1).—Head and nota practically black; eyes red; lateral margins of thorax and median longitudinal stripe or nota white. Abdomen scarlet with three strong black scent-gland areas, the first divided into two lateral parts; there is a small vestigial fourth area. A whitish median longitudinal stripe continues that of thorax; there is another on each side parallel and lateral of scent-glands, and a third stripe similar and parallel just mesad of connexivum which has very small black lateral plates with white outer (laterad) borders giving a white edging to the whole connexivum. Rostrum reaching just pass intermediate coxae; appendages pale-brownish; abdomen beneath pale reddish-yellow with five scarlet longitudinal stripes—one median, one latero-discal, and one in

* Dr. E. Bergroth informs me that the correct orthography is *Rhopalomorpha*.



FIGS. 22, 23.—*Rhopalimorpha obscura*: 22, egg-shell; 23, fifth instar.
FIGS. 24–26.—*Oncacontias vittatus*: 24, egg-shell; 25, egg, showing embryo 26, fifth instar.

connexivum interrupted by lateral plates; three well-marked black ventral plates and a vestige of a fourth. Hemielytral pads reaching posterior edge of metanotum. Length of bug, 4·1 mm.

Fifth Instar (Text-fig. 23).—Much more elongated. Coloration as in third instar (as described above) but more strongly contrasted. The white stripe of nota now extends on to head. Rostrum barely reaches intermediate coxae. Spiracles and trichobothria (setigerous punctures accompanying stigmata, and usually two to every spiracle in Pentatomidae) black and conspicuous. Hemielytral pads reaching half-way down third abdominal segment (segments counted in dorsal view). Length of bug, 7·0 mm.

The newly-emerged imago is a very pale greenish with the median stripe paler still, and the head, thorax, and scutellum suffused with red. The red connexivum shows through the hemielytra. Eyes dark red.

Life-history.

1. Adults collected on Dun Mountain, Nelson, 23rd January, 1923; eggs laid, 24th–25th January; eggs hatched in Wellington, 31st January.

2. Adults collected *in copula*, North Auckland, 12th December, 1923: eggs laid, 15th December; adults again pairing, 19th December; red eye-spots appeared on eggs, 21st December; eggs hatched in early morning, 22nd December; two more eggs laid (these never hatched), 24th December; first ecdysis, 30th December.

It will be noticed that the hot climate of North Auckland caused development to proceed only a very little faster.

As in so many other insects, hatching and emergence appears to take place at night or in the early morning.

The first ecdysis is accomplished by a median longitudinal split which does not include the head cuticle. At the fourth ecdysis the cuticle splits along the latero-caudal edges of the scutellum and between the head and pronotum. In the exuviae the head is strongly deflexed and the rostrum extended along the venter, leaving a wide gap between the occiput and pronotum.

Seasonal Occurrence.

Eggs have been laid in December (North Auckland) and January (South Island, subalpine). Advanced nymphs occur in February and March. Adults have been taken in September to April inclusive and in July; *in copula* in November, December, and January. One imago was found in July in company with wintering nymph ticks (*Haemaphysalis bispinosa*) at the base of a clump of rushes (*Juncus effusus*). Another adult was taken under bark at Lake Wairarapa in September (T. Cockcroft). The imago therefore probably hibernates, and only one generation passes in a year.

Host Plants and Feeding-habits.

Rhopalimorpha obscura bears the pale median stripe which is so often an indication of grass-haunting habits. It is also much more elongated than the species of any other genus in New Zealand.

Sweeping has procured it from miscellaneous herbage, long grass, English grasses, sedges, *Carex* sp., and more specifically from cocksfoot (*Dactylis glomerate* L.), wiwi (*Juncus effusus* L.), and *Carex virgata* Sol. In a swampy pasture at Wainuiomata the close restriction of this bug to clumps of *Carex virgata* was remarkable. On cocksfoot the nymphs and adults feed with avidity on the fully formed but not yet hardened seeds.

Though essentially attached to grasses, sedges, and rushes, this insect may enter the forest where *Carex* sp. grows on the margins of bush-creeks. I believe it to be purely phytophagous.

Distribution.

Hutton (1898B, p. 171) gives the range as "Auckland to Otago," in which he is probably entirely correct. The writer has seen specimens from North Auckland, Auckland, Cuvier Island (R. S. Sutherland), Motutapu Island (David Miller), Lake Roto-aira (E. H. Atkinson), Ohakune (T. R. Harris), Wanganui district, Wellington district, Lake Wairarapa (T. Cockcroft); and in the South Island from the Dun Mountain, Nelson, Little River, Canterbury (T. Lee), West Coast (T. R. Harris).

Kirkaldy has recorded it from French Pass and from the Chatham Islands (1909B, p. 24). The last locality is interesting in view of the fact that these islands possess also the melanic form, *R. ignota* Hutton. *R. obscura* is the only Hemipteron so far recorded from Stewart Island (Howes, 1914, p. 100).

Miscellaneous Notes.

This is easily the most plentiful Pentatomid in New Zealand, to which country it is confined.

The second instar, if not others, feigns death when disturbed, unless it be in strong sunlight.

Numerous examples of adults and nymphs were kept in a dry Petri dish for a week with heads of fairly dry cocksfoot. At the end of that period a cocksfoot-head was dipped in water, shaken to get rid of superfluous moisture, and placed in the dish. In a very short time all the other heads were deserted and the bugs crowded upon the wet one all day.

The female is usually slightly larger and wider, and brownish in colour. The male is distinctly greenish.

Rhopalimorpha ignota Hutton (1898A, p. 159) is not worthy even of subspecific rank. In fact, its author himself omits it altogether from his *Index Faunae* (1904, p. 221). The type in the Canterbury Museum, recently lent to me through the kindness of Mr. Tonnoir, Assistant Curator, is accompanied by an exactly similar specimen labelled "Whangarei," apparently by Hutton himself. Both specimens are rather dark, but that is the only distinction. Hutton writes, "without any smooth band on the head and pronotum," and makes this the chief if not only difference. Yet in the type itself this smooth pale band is discernible on the pronotum with the naked eye. There is a strong tendency to melanism in Chatham Island insects. Thus the Chatham forms of the Cicadid *Melampsalta cruentata* (Fabr.) (see Myers, 1921A, p. 250), and of the Cercopid *Philaenus trimaculatus* (White), are extremely dark.

Oncacontias vittatus (Fabr.). (Plate 86, figs. 2, 3; and text-figs. 24–26.)

Copulation.

On the 28th October, 1922, a pair was captured together, though not actually *in copula*. It was probable that union had occurred previously, and, in any case, it was resumed very soon after capture, but discontinued a few hours later (in the evening). Next day no observations were made, but on the 30th the bugs were *in copula* from 10 a.m. till 1 p.m., on the 31st from 11.30 a.m. till 3 p.m. At 3.45 p.m. oviposition had commenced

and eleven eggs were already laid. When two more had been laid the male returned and copulation was resumed until 4.50 p.m., at which time the female commenced once more to oviposit, but this time at another spot. At 6.20 p.m. the bugs were again *in copula*. The next day saw two long periods of copulation, one at midday and one in late afternoon. The same programme was followed on the two succeeding days; but on the 4th there was no copulation, and on the 6th the male was dead. The female survived till the 15th, and the eggs hatched on the 17th. To sum up, copulation took place for several hours at a time during at least seven days, and had probably commenced before capture. No copulation appeared to take place at night. No feeding during copulation was observed.

During the actual process the female dragged the male backwards wherever she wished. Frequently the female stopped and cleaned her feet by rubbing one on another. Occasionally she struck the male on the underside of his abdomen with a hindmost leg, violently and repeatedly, then with the opposite hind leg—sometimes varying the process by tapping with both alternately—beating a rapid tattoo. The tips of the membrane of the male's hemielytra were turned up dorsally and permanently owing to the fact that when the female went forward the apparently resisting male was habitually slewed round so that his long axis formed a backward continuation of hers, the heads pointing in opposite directions (see Whitmarsh, 1917, fig. 10, where *Nezara hilaris* Say is shown in an exactly similar position). Then, his abdomen being beneath the tip of hers, the slight amount by which his hemielytral membranes extended beyond his abdomen was bent up over his body by the tip of the female's abdomen. Frequently the female shook her whole body in a jerky manner, from side to side, while persistently beating him with her hind feet. On occasion she even spread her wings in an attempt to fly. The male was sometimes on his back, sometimes swinging freely as the female climbed a stem. Occasionally the female was perched on the back of the male, head to head and tail to tail, with her venter appressed to his dorsum. In such a position the torsion of the male organs must be great. Whitmarsh (1917) gives an account of copulation in *Nezara hilaris* showing great similarity to the behaviour of the present species, though these two Pentatomids are rather widely separated taxonomically. The main differences appear to be that copulation may occur in *Nezara* not only at night but all night, and a certain amount of feeding may be done during the act. The copulation periods are much longer than in *Oncacontias* and are extended over a longer period. How far such differences are individual and how far specific has not been ascertained.

Oviposition.

After being *in copula* continuously from 11.30 a.m. and struggling violently from 2.20 p.m., the female at last broke loose at 3 p.m. She went to the farthest end of the vessel and stayed in one place on the side of the glass, where oviposition commenced. At 3.45 p.m. eleven eggs had been laid, and others were being deposited with very little interval between them. There appeared, as viewed through the glass from below, first a droplet of moist substance, which may have signalized either the first contact of the wet ovum with the glass, or else a spot of adhesive to which the egg was to be attached. Then came the egg itself, apparently with considerable labour. It appeared pale green and almost spherical, and was pressed down and continually manipulated by the hindmost legs—chiefly, in fact, by the distal ends of the tibiae, which seemed to pass to and fro rapidly

over a diagonal row of dark spots* (openings ?) on each side of the ventral surface of the abdomen—then applied to the eggs with a stroking motion from apex to base. This last operation was frequently repeated on each egg. The laying of two eggs was observed, and then the male, who had previously arrived on the scene, clambered on the female's back and then departed, came once more, inserted his bulky genital segments from a semi-lateral position and again copulated. The female made the above-described jerks to free herself, pulled the male about the vicinity for some time, and finally settled to quietude *in copula* till 4.50 p.m. Some time before 6 p.m. oviposition was resumed and 6 eggs were laid on the muslin cover. One egg fell from this situation and adhered to the glass farther down the tube. At 6.20 p.m. the bugs were again copulating, the female struggling hard.

Eggs. (Text-figs. 24, 25.)

Egg spheroidal with rounded ends. Length, 1·1 mm. Colour pale green. Fastened apparently by adhesive material. As development proceeds the eyes of the young nymph appear as crimson spots anterior and ventral. Just before hatching the segments are marked dorsally with faint blackish streaks. At hatching the rupture of the chorion is longitudinal. The chorion is transparent, colourless, and so elastic that at hatching the edges immediately turn in and each hemisphere of the empty egg-shell becomes elongated. The whole surface is hexagonally reticulated, though under a low power it appears smooth.

Nymphs.

First Instar.—Pale-greenish, with appendages and connexivum colourless and eyes crimson. Region of scent-glands yellow. The mouth setae appear as a hair-like streak through the transparent labium which reaches past the hind coxae. The whole insect is so flat ventrally and convex dorsally as to appear dome-shaped.

Second Instar (Plate 86, fig. 2).—At first almost uniformly pale green, darkening, however, to the following coloration: Eyes brown, with very distinct facets: antennae pale amber but with basal joint black and ultimate joint somewhat infuscated. Legs pale transparent amber, all appendages with a few black hairs, especially distally; rostrum pale transparent amber infuscated at tip; head shining brownish-black; thoracic nota also black with a hair-like median longitudinal white streak; lateral edges transparent and colourless. Abdomen dorsally pale green with whitish transparent connexivum; depressions along connexivum appear in certain lights as brownish spots; first scent-gland area very large and double, the two lateral halves separated by a continuation of pale median line of thorax; second and third scent-areas very large, transversely elliptical, separated and more or less outlined by narrow reddish line; there appears to be a vestige of a fourth scent-gland area; all scent-gland areas black and evidently heavily chitinized.

Third Instar (Plate 86, fig. 3).—The hair-like median streak of the second instar began towards the end of that stadium to lose the distinctness of its edges and to widen a little; now in the third instar it has widened to a great extent and the only dark colour left on thoracic nota consists of a

* In the female, on each side of the fourth and fifth ventral segments is a circular deeply impressed dark spot, some distance in from the margin. There is thus a pair of these spots on each side of venter. No signs of these are present in the male. It is hoped to investigate these structures more fully at a later date.

lateral band between disc and connexivum on each side, continuous with a little on hind-margin of vertex; the median hair-like stripe of white is, however, still visible traversing a pale dirty area of rhomboid shape. The raised scent-gland areas are still jet-black edged with bright red and then with white; the rest of abdomen is greenish, except the connexivum, which is whitish with a blackish spot (lateral plate?) in each segment. Eyes castaneous; antennae and legs amber with dark tips, as is also the rostrum.

Fourth Instar.—Pale green with a lighter olivaceous tinge on head and connexivum. A median longitudinal narrow white line along thoracic nota. The three scent-gland areas as in previous instar; the second scent-gland area forms the apex of a black V, arms of which extend cephalad to include the two separate portions of first scent-area and finally end on pronotum, thoracic part of the V being olivaceous brown and converging somewhat cephalad. Apex of V is filled with white, as is also the space between second and third scent-gland areas. Ventral surface pale green with a thin black line down each side of head and thorax within inner border of connexivum. Setae of rostrum showing very plainly and darkly through the pale-green labium; eyes dark brown; antennae wine-red, except last segment, which is fuscous or almost black, all articulations white; legs pale olivaceous, claws brown.

Fifth Instar (Text-fig. 26).—Coloration resembling that of fourth instar. Rostrum reaching just past intermediate coxae. It is interesting to note that there is no trace of the conspicuous abdominal spine so pronounced in the imago.

Life-history.

Copulation, 28th October to 3rd November, 1922; eggs laid, 31st October; eggs hatched, 17th November; increased in size and paler in colour, 21st November; ecdysis (first), 24th November; ecdysis (second), 17th December.

The mortality was very heavy, and no bugs were reared beyond this point. Owing to artificial conditions the periods given above are probably not normal. On hatching the young bugs were pale green, transparent, and very inactive, waving their cream-coloured legs only at intervals. All remained clustered near the egg-cases in a manner common to many, if not most, Pentatomids.

Seasonal Occurrence.

The adult bugs have been taken from August to May—that is, in all except the two main winter months. Most have been collected in October and November. They are then less but still moderately abundant till February. The fourth and fifth instars have been taken in January. In the South Island the fifth has occurred in March This clearly indicates that the species hibernates in the adult state, emerges from its shelter in spring, lays its eggs in late spring, passes through the nymphal stages in summer, and goes into hibernation as an adult in late autumn, thus completing the cycle. There is apparently only one brood per year.

Food Plants and Habitat.

I have not found this species to be other than purely phytophagous. The nymph seems more restricted than the adult, since the latter may be beaten from a variety of shurbs and bushes, while the former is more plentiful on grasses and allied plants, but in no stage does this bug appear very specialized in its feeding-habits. Nymphs have been taken from toetoe (*Arundo conspicua* Forst. f.) and konini (*Fuchsia excorticata* (Forst.) L.).

The adult has occurred on grasses, herbage, *Plagianthus divaricatus* Forst., various bushes, and on ferns, but by far the greater number have been found crawling or even flying in the hot sunshine on fences, walls, roads, and paths, and in spring and in autumn, evidently emerging from hibernation shelters in the former season and seeking them in the latter.

Distribution.

This bug occurs in flax (*Phormium*) swamps, in the forest itself, but especially in secondary growth, and in subalpine scrub. The altitudinal range is from sea-level to 3,000 ft. Specimens on a glacier on Mount Ruapehu at 7,500 ft. were probably blown to an elevation beyond their normal range.

North Island localities range from Lake Taupo (E. H. Atkinson), Mount Ruapehu (Miss Stella Hudson), and Ohakune (2,100 ft., T. R. Harris), to Hastings, Wanganui, Tararua Range, Waikanae, and Wellington. In the South Island it has been collected at Mount Arthur (T. Cockcroft), Greymouth (T. Cockcroft), West Coast (T. R. Harris), Arthur's Pass (J. G. M.), Kaituna (S. and C. Lindsay), Little River (T. Lee), and Lake Wakatipu (G. V. Hudson). Hutton (1898B, p. 171) gives the range as "Auckland to Otago." It is probably generally distributed throughout both Islands.

Miscellaneous Notes.

There are indications that this beautiful species is distasteful to spiders. It has been found hanging quite fresh and untouched in the web of a full-grown Epeirid (*Araneus pustulosus* (Walck.)). The Peckhams (1898, p. 161) as the result of an experiment (quoted fully in Myers, 1922, p. 3) decided "that stink-bugs are protected from spiders." Although the colour of *Oncacontias* might be construed as procryptic when the insect is among its food-plants, yet the imago when searching for or leaving hibernation shelter is one of the most conspicuous insects in New Zealand, while the nymph is well-marked with white, black, and crimson on the green ground-colour. It is interesting that the white, black, and red, which in so many insects, notably the Hymenoptera, are well known to be warning colours, should be displayed solely round the orifices of the repugnatorial glands. Moreover, in nearly all the other terrestrial Heteroptera these gland-openings are marked with some one or other of these colours, usually black. On the other hand, in the case of the nymphal *Oncacontias* the white, black, and red may function in the same way as the bold slashes of colour on the green sides of the privet-caterpillar (*Sphinx ligustri* L.), which are said to break up the outline and render the large larva less conspicuous than if it were uniformly green.

Miss Stella Hudson (1922, p. 94) found this species represented in a considerable deposit of insects on the surface of a glacier on Mount Ruapehu at an elevation of 7,500 ft. (see under *Nysius clavicornis*).

There is a very distinct and remarkably constant form of this species characterized by the total replacement of green in the colour-scheme by brilliant red. For specimens of this very handsome insect the writer is indebted chiefly to Mr. G. V. Hudson, who has taken it in some numbers, almost solely from the living foliage of rimu (*Dacrydium cupressinum* Sol.), as the records of the following specimens examined by me will indicate: Eight specimens from live rimu foliage, Makara Bush, Wellington, April, May, 1923; three specimens from the liliaceous epiphyte, *Astelia* sp., in the top of a recently felled rimu, Korokoro, Wellington, September, 1921. This is the only intimate attachment known between a New Zealand heteropteron and a gymnosperm.

Family 19 (43). Cydnidae.

Hahnia australis Erichs.

Seasonal Occurrence.

I have seen only the adult, and that in October, November, April, and May. In the three former months it occurred on roads, running actively in strong sunlight. In May it was not uncommon under stones on the foreshore among closely-grazed turf at Lyall Bay, Wellington.

Distribution.

My specimens are all from the Wellington district. Hutton (1898b, p. 172) gives "Auckland to Canterbury" as the range. Kirkaldy (1909b, p. 25) says it is "distributed over Australia, Tasmania, New Caledonia, and Ceylon."

Miscellaneous Notes.

Buchanan White (1878, p. 275) writes; "A note is appended to one of Mr. Wakefield's specimens stating that he 'once found this in numbers on the sea-beach at Sumner, either floating in salt-water pools or crawling on the sand.'"

Chaerocydnus nigrosignatus F. B. W.

This endemic species appears to be very rare. The only three specimens I have seen were taken, one in a burrow on the sandy beach at Rona Bay, Wellington (J. Roberts), and the second and third in the South Island, at New River (A. Philpott). All three were taken in the last week in November. Hutton (1898b, p. 172) gives the range as "Canterbury and Otago."

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New Zealand Amphipoda: No. 6.

By Chas. Chilton, M.A., D.Sc., F.L.S., &c., Professor of Biology, Canterbury College.

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EUTHEMISTO.

Euthemisto antarctica Dana and **Euthemisto gaudichaudii** Guérin.

A species of *Themisto* is frequently washed up on the shores of New Zealand, but the identification of it has given rise to a considerable amount of uncertainty and difference of opinion. In 1879 specimens were examined by Mr. G. M. Thomson, and by him were referred to *Themisto antarctica* Dana. He quoted the description given by Spence Bate in his *Catalogue of the Amphipoda in the British Museum*, and added a description of the female and of the young taken from the incubator pouch. In the "Challenger" Report Stebbing identified one of the species collected with that described by Thomson, but gave it the new name of *Euthemisto thomsoni*, being of opinion that it was different from Dana's species. In the "Challenger" Report he also recorded specimens of *E. gaudichaudii* Guérin, and figured this as well as the species which he called *Euthemisto thomsoni*. The chief character which induced Stebbing to consider the New Zealand specimens distinct from Dana's species was that the body is usually dorsally carinated in the adult animals, while this carination is not mentioned by Dana. In 1889, however, Bovallius pointed out that the development of the carina is a varying character in all the species that he had examined, and is usually less distinct in an ovigerous female than in a male of the same size. For this and for other reasons he concluded that Stebbing was not correct in his identifications, but that his *E. gaudichaudii* was really the same as *E. antarctica* Dana, while his *E. thomsoni* was identical with *E. gaudichaudii* Guérin.

I have examined specimens washed up at different times on various parts of New Zealand coast, and, while there is not much doubt that they are the same as those described by Stebbing under the name *E. thomsoni*, I have been unable to determine whether this should be referred to *E. gaudichaudii*, as Bovallius thinks, or to *E. antarctica*. Of these two "species" Bovallius (1889, p. 295) says, "They are closely allied, and less easily distinguished from one another than the two northern forms; the best distinguishing mark being, however, the relation between the length of the first and second pairs of uropoda." I have been unable to distinguish my specimens into these two groups by this character, and the last manuscript note that I had made about them was that the two species appeared to be identical.

Shortly afterwards I received Dr. K. Stephensen's final report on the Hyperiidea of the Danish Oceanographical Expedition, 1908–10, to the Mediterranean and the adjacent seas. In this he uses the generic name *Themisto* to include *Parathemisto* Boeck and *Euthemisto* Bovallius, and unites the two northern species *T. compressa* Göes and *T. bispinosa* Boeck under the name of *T. compressa*. He gives elaborate descriptions and comparisons of different specimens obtained by the Danish expedition,

grouping some of them under one or the other of the two forms *compressa* and *bispinosa*, while other specimens he considers intermediate between these two. The point of interest for New Zealand workers is that Stephensen unites *Euthemisto antarctica* Dana with *E. gaudichaudii* Guérin, and considers that both should be united with *Themisto compressa* of northern seas. His figures and descriptions leave little doubt that this conclusion is correct, and the result is that *T. compressa* must be looked upon as a bipolar species, being found in the Atlantic north of 40° N. lat., and in the southern seas south of 35° S. lat., while it appears to be altogether lacking in the intervening area.

It is interesting to note that in this case we have a species occurring with two forms in the colder northern seas and reappearing in two similar forms in the colder southern seas. I have drawn attention to a similar example in the case of the amphipods known as *Ampelisca eschrichtii* and *A. macrocephala* (1917, p. 75).

THE NEW ZEALAND SPECIES OF PODOCERUS.

I have always been puzzled to distinguish the different species or forms of *Podocerus* found in New Zealand. *P. cristatus* (G. M. Thomson) was described by Mr. Thomson in 1879 under the name *Cyrtophium cristatum*, and it was easy to identify some of the forms found on the New Zealand coast with this species as described by him. In the same year Haswell independently described *C. dentatum*, an Australian form which Stebbing has—I think, rightly—considered to be the same as *P. cristatus*: in 1885 Haswell placed this species in the genus *Dexiocerella*.

The New Zealand species are common on the coast, frequently being found at the roots of seaweed, on the sea-squirt *Boltenia*, and on other organisms which they usually closely resemble in colour; as they are also somewhat sluggish in movement, they are sometimes hard to distinguish. They appear to show considerable variation in breadth of body, length of the appendages, colour, &c. Other specimens were at different times taken on sertularians, which they so closely resembled that on more than one occasion they were nearly being overlooked altogether, although it was known that they were frequently found on the hydroids. Some of these appeared at first sight narrower than the others, and it was thought they had probably formed a separate species. Closer examination, however, usually failed to reveal any striking or constant difference.

In 1885 Haswell had described another species, under the name *Dexiocerella laevis*, from Australian shores, differing from *D. dentata* mainly in having none of the segments dorsally produced.

In his *Das Tierreich Amphipoda*, published in 1906, Stebbing transferred these and other species to the genus *Podocerus*, recognizing ten species, two of them being *P. laevis* (Haswell) and *P. cristatus* (G. M. Thomson), the latter including *Dexiocerella dentata* Haswell. More recently I have examined and mounted numerous specimens, males and females, from different parts of Australia and New Zealand. Some of them it is easy to identify as *P. laevis*, and others as *P. cristatus*, in accordance with the descriptions given by Stebbing, and I think it is desirable to retain these two species distinct as a matter of convenience, though other forms are to a large extent transitional in one character or another. In *P. laevis* the body is usually smooth, without dorsal carination or with only slight indications of such. The gnathopoda are somewhat short and stout, in

the first the carpus being short and having a distinct rounded lobe fringed with setae extending along nearly its whole length. The second gnathopod has the propod short and stout, fully half as broad as long, the palm is nearly straight, and in fully-grown specimens bears two or three somewhat blunted teeth, and is irregularly dentate near the base of the finger. In the peraeopoda the propods bear three or four stout setules, the strongest of them being on the proximal portion of the propod.

On the other hand, *P. cristatus* usually has the body more or less carinate on the posterior segments of the peraeon and of the pleon. The gnathopoda are more elongated, the carpus of the first being more slender and having the lobe extending only along part of its length. The second

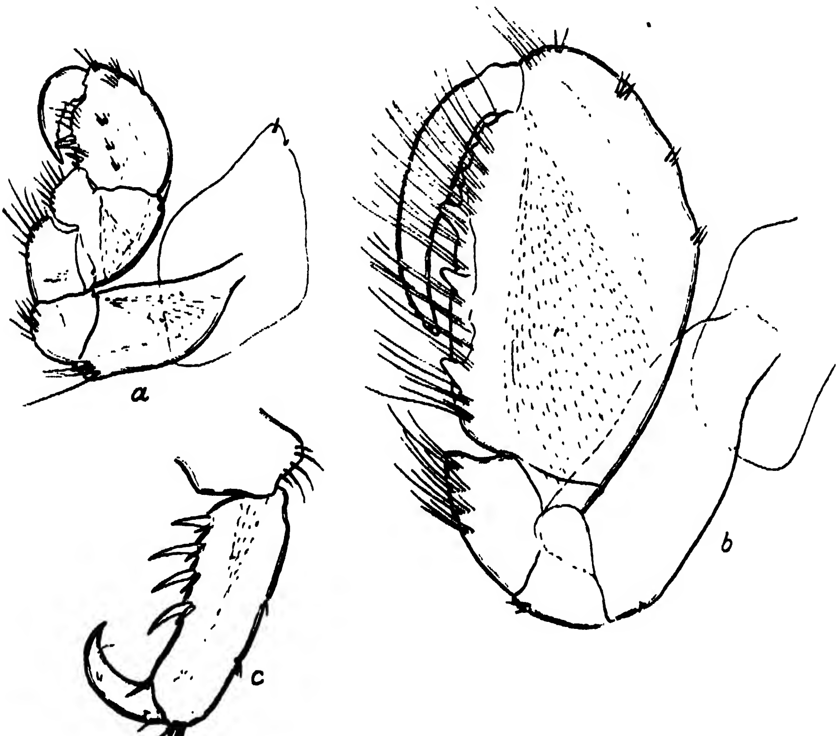

FIG. 1.—*Podocerus laevis* (Haswell): male specimen from Cape Maria van Diemen. *a*, first gnathopod; *b*, second gnathopod; *c*, propod of peraeopod.

gnathopod in general resembles that of *P. laevis*, but is more elongated, being more than twice as long as broad. The peraeopoda have the setules on the propods less stout, and those that are present more evenly distributed along the margin.

In many respects *P. cristatus* shows an approach towards *P. danae* Stebbing from Kerguelen Land, but in that species all the segments of the body, including the head, bear carinate teeth or processes, and the appendages, especially the second antennae and gnathopoda, are much more elongate. I have specimens from China and Japan that I feel inclined to consider a variety of *P. danae*, the only appreciable difference being that the carinal processes are rounded, instead of being pointed as

in the Kerguelen Land specimen. *P. brasiliensis* Dana from the tropical Atlantic is in many respects similar to *P. cristatus*, but is described as having the body not carinate. I have only one specimen of *P. variegatus* Leach, the species commonly found in the North Atlantic, and this again

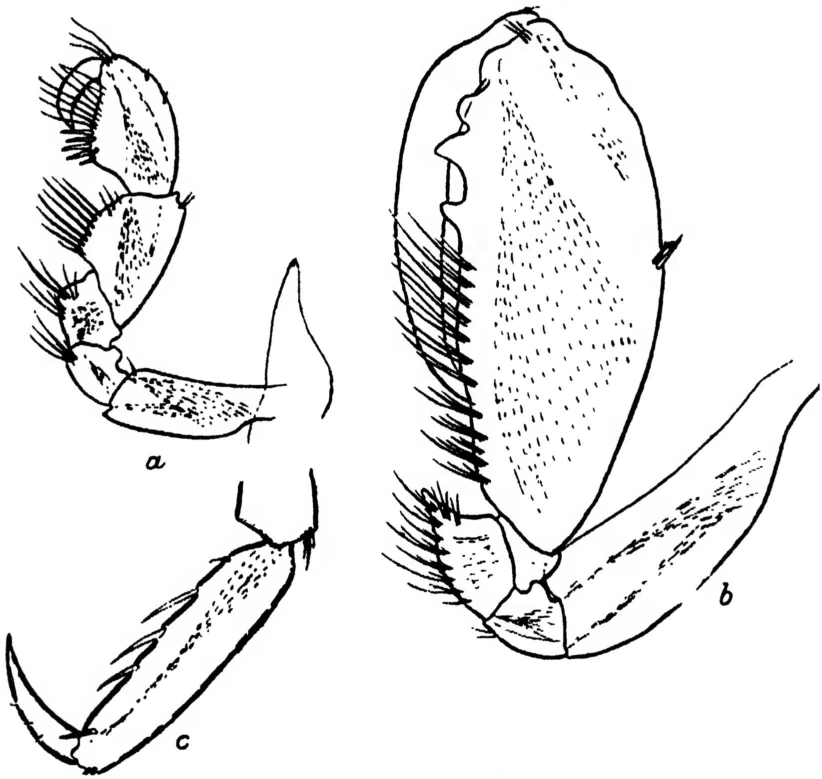

FIG. 2.—*Podocerus cristatus* (G. M. Thomson): male specimen from Cook Strait. *a*, first gnathopod; *b*, second gnathopod; *c*, propod of peraeopod.

shows very close approach both to *P. laevis* and *P. cristatus*, and it is not surprising that in 1893 Della Valle grouped most of these species under the name *P. brasiliensis*.

Barnard (1916, p. 277) has recorded *Podocerus cristatus* (G. M. Thomson) from False Bay, South Africa.

THE NEW ZEALAND SPECIES OF ALLORCHESTES.

In his report of the Crustacea of the United States Exploring Expedition Dana gives two species of *Allorchestes* as occurring in New Zealand, both collected in the Bay of Islands.

A. brevicornis seems from the figure to be immature, and Stebbing (1906, p. 584) has rightly suggested that it is perhaps a young male of a *Hyale*; it is, I think, a specimen of *Hyale grandicornis* Kroeyer, a species found on the shores of all subantarctic lands. The genera *Hyale* and *Allorchestes* closely resemble each other, and are not easy to distinguish.

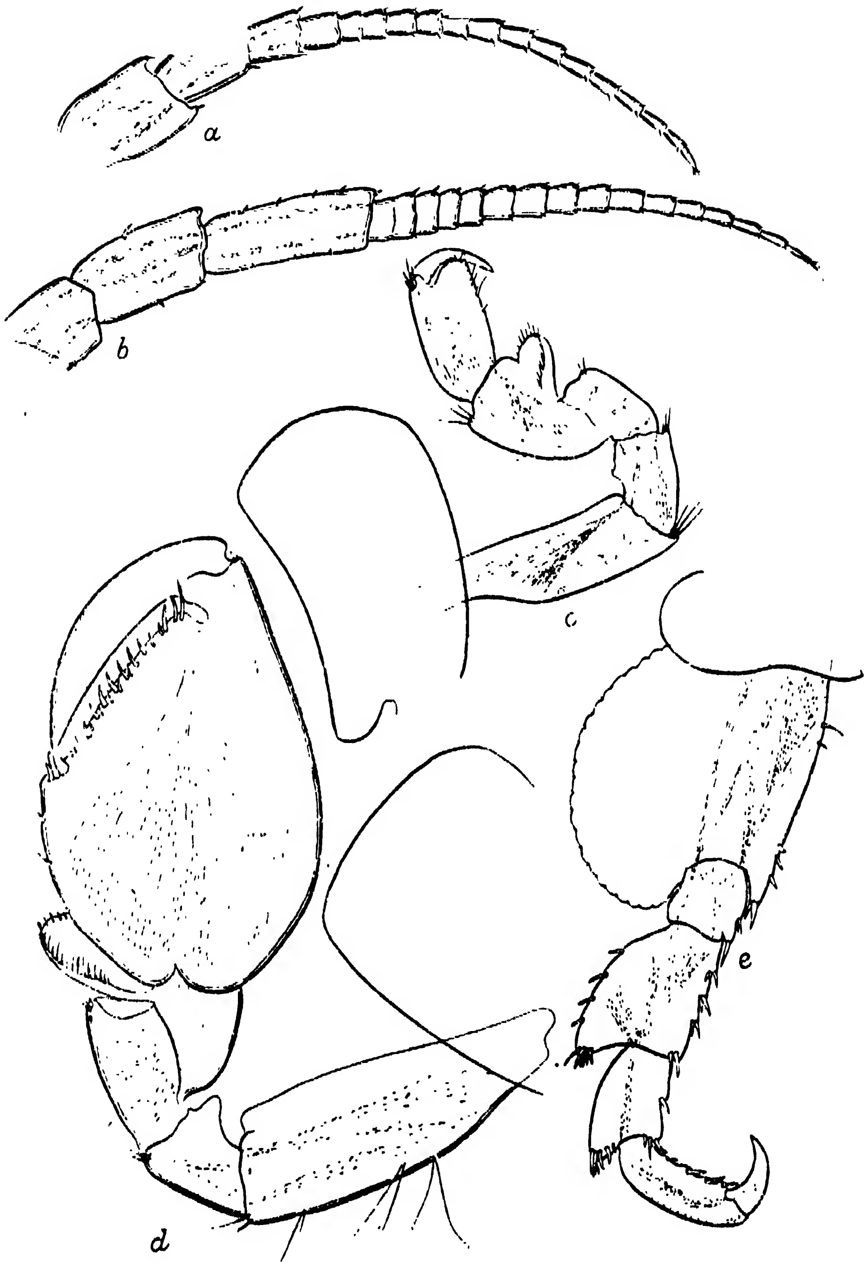

Fig. 3.—*Allorchestes novizealandiae* Dana: male. *a*, first antenna; *b*, second antenna; *c*, first gnathopod; *d*, second gnathopod; *e*, third peraeopod.

In young males of *Hyale grandicornis*, and perhaps of other species, the carpus of the second gnathopod is produced into a process lying between the merus and propod, similar to the one normally found in adult males of *Allorchestes*. This process is also present in the females of both genera; in many cases it cannot be demonstrated without dissection of the appendage, and its value as a generic character is accordingly reduced. The shape of the telson differs in the two genera, but this character again is one that is not always readily observed.

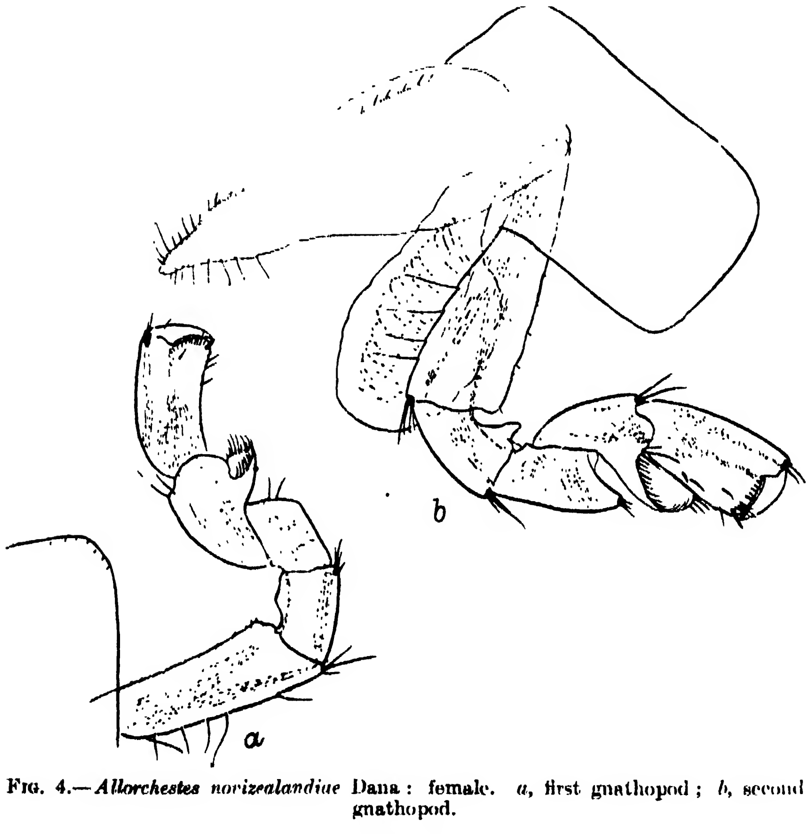

FIG. 4.—*Allorchestes novizealandiae* Dana: female. *a*, first gnathopod; *b*, second gnathopod.

It is not surprising, therefore, that the identifications of *Allorchestes novizealandiae* made up to the present are somewhat uncertain. Fortunately I am able to give below a distinguishing character which is, I think, quite reliable, though it is well marked only in adult males.

Allorchestes novizealandiae Dana.

Allorchestes novizealandiae Dana, 1853 and 1855, p. 894, pl. 61, fig. 1 *a–f* (male), *g–v* (female). *Allorchestes novizealandiae* Stebbing, 1906, p. 581 (with synonyms). *Hyale chiltoni* G. M. Thomson, 1899, p. 206.

This species was described and very fully figured by Dana in 1852, and, though it has been referred to by both Mr. G. M. Thomson and myself

on various occasions, I have never quite felt sure about the correctness of our identifications. In 1899 Mr. G. M. Thomson described a new species, which he named *Hyale chiltoni*, well marked by the peculiar character of the first gnathopod of the male, the dactyl being long and curved and projecting far beyond the short palm. Subsequently to that date I have had specimens from different localities that I had no hesitation in referring to Thomson's *Hyale chiltoni*, and this was confirmed by comparison of them with mounted specimens so named in Mr. Thomson's own collection. Examination of them, however, showed that in the male the second gnathopod has the carpus produced into a narrow lobe as described by Stebbing for the genus *Allorchestes*, and in the telson and other points the specimens also agree with this genus, and I had accordingly labelled my specimens "*Allorchestes chiltoni* (G. M. Thomson)."

In comparing this species with the description and figures of *Allorchestes novizealandiae* as given by Dana, my attention was specially drawn to the figure he gives of the first gnathopod of the male, which differs considerably from that of the form found in some other species of *Allorchestes*, but proved to be a fairly accurate representation of the corresponding appendage of *Hayle chiltoni* G. M. Thomson; and a comparison of the other appendages leaves no doubt that the species described by Dana was the one subsequently described by G. M. Thomson under the name of *Hyale chiltoni*, a name which will therefore have to be reduced to a synonym.

The figures given by Dana agree very well indeed with those of my specimens, perhaps the only important point being that the joints of the peduncle of the second antenna are not very slender as he describes, but of fairly average breadth.

Dana's specimens were taken in the Bay of Islands on the shores of Parua Harbour, the animals being found in holes in wood that had been bored by teredos. I have specimens from Dunedin, Lyttelton, Timaru, Cape Campbell, Cape Maria van Diemen, and other parts of the New Zealand coast; also from Chatham Islands. Dana mentions that this species is near to *A. australis* Dana, an Australian species which Stebbing has considered to be the same as *A. compressa* Dana. In the localities given by Stebbing for *A. novizealandiae*, Valparaiso is given with a query, but so far I have been unable to ascertain the authority for this.

The figures illustrating this paper have been kindly drawn for me by Miss E. M. Herriott, M.A., Assistant in the Biological Laboratory of Canterbury College.

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The New Zealand Crustacea Euphausiacea and Mysidacea.

By CHAS. CHILTON, M.A., D.Sc., LL.D., &c., Professor of Biology, Canterbury College, New Zealand.

[*Read before the Philosophical Institute of Canterbury, 6th August, 1924; received by Editor, 31st December, 1924; issued separately, 26th April, 1926.*]

VERY little attention has been devoted hitherto to the New Zealand Euphausiacea and Mysidacea. A few species were taken by the "Challenger" in New Zealand seas, and were described by G. O. Sars in his report on the Schizopoda collected by that expedition. One or two additional species were afterwards added by Mr. G. M. Thomson and myself. Most of these have been reviewed by Hansen in subsequent papers, and later by Tattersall in his reports on the specimens collected by the British Antarctic ("Terra Nova") Expedition, 1910. The publication of the "Terra Nóva" reports makes it possible to give complete lists of the species known from New Zealand up to the present.

The two groups Euphausiacea and Mysidacea, previously grouped together under the Schizopoda, are now looked upon as separate orders, and it will be well to deal with them separately.

EUPHAUSIACEA.

The Euphausiacea are pelagic forms which are only occasionally washed up on New Zealand shores. Many are subtropical, but others attain their greatest development in size and in numbers in the colder waters of Antarctic and Subantarctic regions, where they frequently occur in enormous shoals and form an appreciable part of the food of whales, seals, seagulls, and other animals.

Before the publication of Dr. Tattersall's paper only eight species were known from New Zealand, chiefly as the result of the "Challenger" Expedition. The "Terra Nova" collections were made mostly to the north of New Zealand, almost on the fringe of the Tropical Zone. They comprise twelve species, of which only five had been previously recorded in this area; the remaining seven were all species known from tropical and subtropical seas, and may here reach, or approach, the southern limit of their range.

The list of the fifteen species now known from the New Zealand area is as follows:—

1. *Thysanopoda obtusifrons* G. O. Sars.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 16.)
   A tropical and subtropical form of wide distribution.
2. *Nyctiphanes australis* G. O. Sars.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 16.)
   Frequently washed up on the beaches in the south of New Zealand; luminous. Confined to temperate seas of southern Australia and New Zealand.
3. *Euphausia recurva* Hansen.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 17.)
   A southern subtropical and temperate species in the Atlantic and Indian Oceans, and widespread over the Pacific.

4. *Euphausia lucens* Hansen.
   Occurrence: Between New Zealand and Australia. (Tattersall, 1924, pp. 4, 19.)
5. *Euphausia similis* Sars var. *armata* Hansen.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 19.)
6. *Euphausia tenera* Hansen (= *E. gracilis* Sars).
   Occurrence: Australian seas off Port Jackson. ("Challenger.") (Tattersall, 1924, p. 4.)
7. *Euphausia spinifera* G. O. Sars.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 26.) A South Temperate form.
8. *Pseudeuphausia latifrons* Sars.
   Occurrence: Australian seas off Port Jackson. ("Challenger.") (Tattersall, 1924, p. 4.)
9. *Thysanöessa gregaria* G. O. Sars.
   Occurrence: North of New Zealand. (Tattersall, 1924, p. 27.) Widely distributed in North and South Temperate Zones.
10. *Nematoscelis microps* G. O. Sars.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 28.) Identification of New Zealand specimens doubtful. Widely distributed in tropical and subtropical waters.
11. *Nematobrachion flexipes* Ortmann.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 29.) Tropical Atlantic and Pacific; Indian Ocean.
12. *Stylocheiron carinatum* Sars.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 30.) Widely distributed in upper waters of tropical and subtropical oceans.
13. *Stylocheiron suhmii* G. O. Sars.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 30.) Widely distributed in tropical and subtropical waters.
14. *Stylocheiron longicorne* G. O. Sars.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 30.) Widely distributed in tropical and subtropical waters.
15. *Stylocheiron abbreviatum* G. O. Sars.
    Occurrence: North of New Zealand. (Tattersall, 1924, p. 31.) Widely distributed in tropical and subtropical waters.

Dr. Tattersall groups the New Zealand species according to their distribution as follows:—

1. Coastal species:—
   Pseudeuphausia latifrons.
   Nyctiphanes australis.
2. Oceanic species more or less widely distributed in the South Temperate Zone:—
   Euphausia recurva.
   Euphausia lucens.
   Euphausia similis var. *armata.*
   Euphausia spinifera.

3. Oceanic species more or less widely distributed in the North and South Temperate Zones, but rarely found in tropical waters :—
Thysanoëssa gregaria.

4. Oceanic species more or less widely distributed in tropical and sub-tropical waters :—
Euphausia tenera.
Thysanopoda obtusifrons.
Nematoscelis microps.
Nematobrachion flexipes.
Stylocheiron carinatum.
Stylocheiron longicorne.
Stylocheiron suhmii.
Stylocheiron abbreviatum.

MYSIDACEA

The Mysidacea are a group usually much smaller in size than the Euphausiacea. They are nearly all marine, being found in shallow waters near the coast, or in some cases in deeper waters; a few live in brackish or fresh water. In New Zealand, previous to Tattersall's paper, three good species, and two doubtful, had been recorded from New Zealand, the good species being *Siriella denticulata* (G. M. Thomson) (1880), *Tenagomysis novae-zealandiae* G. M. Thomson (1900), *T. tenuipes* Tattersall (1918), the last from Carnley Harbour, Auckland Islands. In 1881 Mr. T. W. Kirk described a New Zealand species under the name *Mysis meinertzhagenii*, but the description is insufficient, and all attempts to trace the type specimen have failed. Calman in 1908 recorded a species from New Zealand which he referred to the genus *Pseudomma*, but the specimen was too immature to name specifically.

In the collections of the "Terra Nova" twelve species were obtained off the coast of New Zealand, only one, *Siriella denticulata*, having been recorded from this district previously. Of the twelve species, seven are described as new, six of them being referred to the genus *Tenagomysis*. To these Dr. Tattersall adds another new species of *Tenagomysis* from specimens sent him by myself. This genus, which is unknown elsewhere, is the characteristic Mysid genus of New Zealand.

The list of New Zealand genera therefore stands as follows :—

Suborder LOPHOGASTRIDA.

1. *Paralophogaster glaber* Hansen.
   Occurrence: North of New Zealand. (Tattersall, 1923, p. 279.) This species was hitherto known only from the East Indian Archipelago.

Suborder MYSIDA.

2. *Siriella thompsonii* (H. M.-Edw.).
   Occurrence: New Zealand waters between Three Kings and North Cape. (Tattersall, 1923, p. 280.) Very generally distributed in tropical and subtropical waters.

3. *Siriella denticulata* (G. M. Thomson).
   Occurrence: North of New Zealand; Auckland Harbour; Hawke's Bay; Lyttelton Harbour; Ocean Beach, Dunedin. (Tattersall, 1923, p. 280.) A littoral species known only from New Zealand.

4. *Gastrosaccus australis* Tattersall.
   Occurrence: North of New Zealand. (Tattersall, 1923, p. 282.) A shallow-water species known only from this locality.
5. *Euchaetomera typica* Sars.
   Occurrence: North of New Zealand. (Tattersall, 1923, p. 283.) Widely distributed in Atlantic and Pacific Oceans.
6. *Euchaetomera oculata* Hansen.
   Occurrence: North of New Zealand. (Tattersall, 1923, p. 284.) Previously known from the East Indian Archipelago and the Indian Ocean.
7. *Tenagomysis novae-zealandiae* G. M. Thomson.
   Occurrence: Not taken by the "Terra Nova," but redescribed by Dr. Tattersall from type specimens and others sent to him. (Tattersall, 1923, p. 291.) An estuarine species capable of living in fresh water; recorded from various localities in the South Island and from Lake Waikare in the North Island.
8. *Tenagomysis chiltoni* Tattersall.
   Occurrence: Tidal inlet, Parakai. (Tattersall, 1923, p. 292.) Known as yet from this locality only.
9. *Tenagomysis similis* Tattersall.
   Occurrence: Bay of Islands; Ocean Beach, Dunedin. (Tattersall, 1923, p. 293.)
10. *Tenagomysis macropsis* Tattersall.
   Occurrence: North of New Zealand; Akaroa; Ocean Beach, Dunedin. (Tattersall, 1923, p. 294.)
11. *Tenagomysis robusta* Tattersall.
   Occurrence: North of Auckland. (Tattersall, 1923, p. 295.)
12. *Tenagomysis thomsoni* Tattersall.
   Occurrence: North of Auckland. (Tattersall, 1923, p. 296.)
13. *Tenagomysis producta* Tattersall.
   Occurrence: Sandy pool, Bay of Islands. (Tattersall, 1923, p. 297.)
14. *Tenagomysis scotti* Tattersall.
   Occurrence: North of New Zealand, near the Three Kings Islands. (Tattersall, 1923, p. 298.)
15. *Tenagomysis tenuipes* Tattersall.
   Occurrence: Carnley Harbour, Auckland Islands; taken by the Australasian Antarctic Expedition. (Tattersall, 1923, p. 299.)

The genus *Tenagomysis* now contains nine species, all of them confined to the New Zealand area.

Dr. Tattersall gives a useful key to the species on p. 290.

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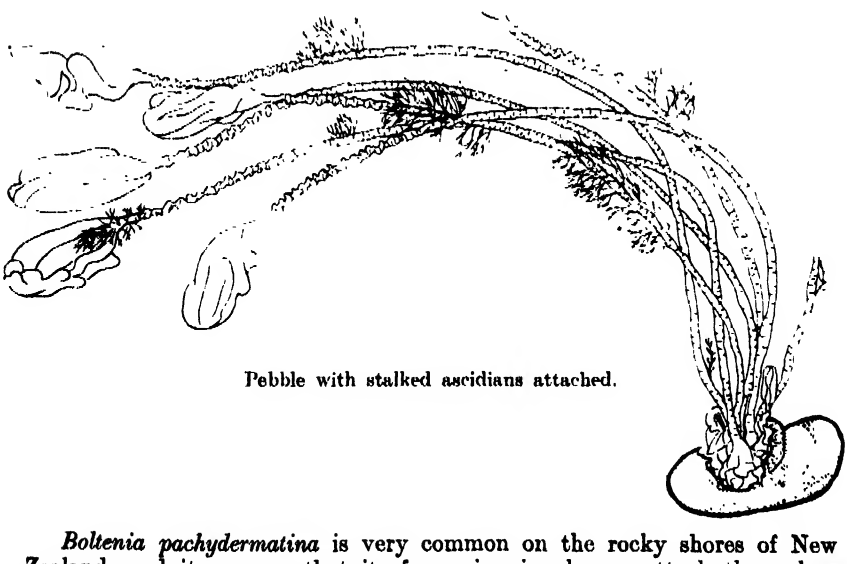
Dispersal of Pebbles and Marine Organisms.

By CHAS. CHILTON, M.A., D.Sc., &c., Professor of Biology, Canterbury College, New Zealand.

[*Read before the Philosophical Institute of Canterbury, 2nd April, 1924; received by Editor, 31st December, 1924; issued separately, 26th April, 1926.*]

IN February, 1923, I picked up on the beach at Riverton, on the south coast of New Zealand, a small smooth stone on which were growing a number of the stalked ascidian *Boltenia pachydermatina* Herdman. The ascidians with the stone had evidently been washed up on to the beach by the waves. This reminded me that several years previously the late Mr. Thomas Forrester, of Oamaru, had called my attention to the fact that smooth-surfaced stones with Boltenias attached were frequently washed up on the shores near Oamaru. In this case the pebbles were apparently river-worn stones brought down by the Waitaki River (the mouth of which is about fourteen miles north of Oamaru), which had afterwards been lying in the shallow water on the adjacent beach.



Pebble with stalked ascidians attached.

Boltenia pachydermatina is very common on the rocky shores of New Zealand, and it appears that its free-swimming larvae attach themselves to the stones lying near the mouth of the river or on the shore, and gradually grow until they are sufficiently buoyant to enable the stone to be floated away, either by the current of the river or by the wash of the waves. In this way it appears that stones may be transported to considerable distances and left in places where perhaps their presence might not easily be accounted for if these facts were unknown.

The stone from the Riverton beach is a rather flat one, probably beach-worn; it measures about 3 in. by 2½ in. by 1½ in., and weighs about ½ lb.

In order to ascertain, if possible, how far the stone had travelled, I submitted it to Professor Speight, who has kindly examined it, and states that it is a somewhat fine-grained granite, similar in many respects to other granites found in Longwood Ranges, Southland (*e.g.*, near Orepuki), and that it may have drifted round the coast, as these granites are chiefly found on the western watershed of the range, or it may have come out of the Sounds area farther west.

On the stone there were growing about a dozen Boltenias, the stalks being about 12 in. to 15 in. long, some of the Boltenias being apparently mature, although much smaller in proportion to the length of the stalk than is often the case with those growing on fixed rocks. Others show younger stages with shorter stalks. Growing on the stalks of the Boltenias were tufts of hydroids and polyzoa of various species, and one or two small barnacles; at the base there is a small mussel, *Mytilus* sp., almost covered with a coralline, portions of which are also growing on the stalks of the *Boltenia*. It is evident, therefore, that various marine organisms, such as hydroids, cirripedes, &c., might be transported in this way along with Boltenias and the stone.

Mr. John Hardcastle, of Timaru, has written to me calling attention to the fact that about twelve years ago a series of heavy southerly seas caused the stranding along many miles of the shingly beach south of Timaru of a large quantity of stalked ascidans which had grown in bunches, usually to the number of twenty or more in each bunch. Among the bunches a small percentage brought ashore, entangled among their holdfasts, a small number of pebbles. In this case apparently the ascidians had been rooted on to a sea-bed composed of gravel.

Mr. C. D. Gilling also tells me of the frequent stranding of many ascidians on the shingly beach north of Timaru. He has sent me samples, many of which are attached to smooth river- or beach-worn pebbles, most of them, however, being much smaller than the one found at Riverton.

It is, of couse, well known that seaweeds and other plants with portions of rock attached to them are frequently detached by the waves during storms and floated to distant parts.* In these cases the portions of rock generally show fracture, and have rough and angular surfaces. The cases to which I am now calling attention are slightly different, since the pebbles are either river- or beach-worn, and, when the Boltenias have grown sufficiently, are floated away by the normal action of the river-current or by the waves, processes which are constantly going on.

The drawing illustrating this paper has been prepared by one of my students, Miss Beryl Parlane.

* Thus Geikie in his *Text-book of Geology* says: "There occur in different parts of the Carboniferous system scattered pieces and even blocks of granite, gneiss, quartzite, or other durable material which lie embedded, sometimes singly, sometimes in groups, in limestone, sandstone, and in coal. Various explanations have been proposed to account for these erratics, some writers having even suggested the action of drifting ice. The stones were most probably transported by floating plants. Seaweeds, like our living *Fucus*, with their rootlets wrapped round loose blocks might easily be torn up and drifted out to sea, so as to transport and drop their freight among corals and crinoids living on the bottom."—(*Text-book of Geology*, 4th ed. vol. 2, p. 1016.)

Similarly, Mr. E. J. Dunn says: "Seaweeds grow on pebbles at the bottom of the sea; as the plants become larger, or as more numerous bladder-like processes form on them, they become so buoyant as to lift the stone off the bottom, and then the tide or current conveys the seaweed with the attached pebble ashore." He gives a photograph of a pebble of volcanic ash 4 in. long, floated inshore and deposited on a sandy beach in Mercury Bay, North Island of New Zealand, by a seaweed (bladder-wrack) that grew upon it.—(*Pebbles*, p. 67, pl. 60, Melbourne, 1911.)

Food of New Zealand Fishes.

By W. J. PHILLIPPS, F.L.S.

[*Read before the Wellington Philosophical Society, 28th October, 1924; received by Editor, 12th November, 1924; issued separately, 26th April, 1926.*]

A PAPER dealing with the food-supply of New Zealand fishes was published in 1892,* and in 1921† records of the food of over thirty species were made by the same author. In the first work are compilations of food in 12,000 stomachs examined by lighthouse-keepers, and in the second there are valuable contributions to our knowledge of the food of common species in Otago waters.

The examination of 114 stomachs of ten species discussed in this paper was undertaken with a view to obtaining preliminary data on the exact nature of food-supply of fishes during the autumn months in Palliser Bay and Cook Strait. Fish taken from the stomachs were examined in like manner to ascertain their food-supply, which was invariably found to consist of copepod-remains, algae, shrimps, and squids.

I have to thank Professor W. B. Benham, F.R.S., of the Otago University, for undertaking the identification of the worms from the fishes' stomachs. I wish also to thank Professor Chas. Chilton, D.Sc., of the Canterbury University College, Christchurch, for assistance in connection with the identification of the Crustacea, and Mr. W. R. B. Oliver, F.L.S., for assistance with shell-fish.

The following details show the nature of the stomach-contents of a number of fish from Palliser Bay, Cook Strait, &c.:—

DACTYLOPAGRUS MACROPTERUS (*Forster*): TARAKIHI.
Trawled in Palliser Bay, Cook Strait, April, 1922.

No.	Worms.	Spatangoid Sea-urchin.	Algae.	Other Materials.
1	*Glycera ovigera, Limbriconereis sphoerocephala*, &c.	Remains ..	Quantity ..	Copepod eggs.
2	*Limbriconereis* sp.	Remains ..	..	Diatoms ?
3	..	Several ..	Quantity ..	..
4	*Owenia fusiformis*	..	Small quantity	..
5	..	Remains ..	Small quantity	Crabs and starfish remains.
6	.	..	In intestine ..	..
7	..	Remains ..	Quantity ..	*Malletia australis*; sand and gravel.
8	..	..	Quantity ..	Sand and gravel.
9	Traces	Traces ..	..	*Malletia australis*; sand and gravel.
10	Traces	..	Small quantity	Some sand.
11	..	Remains ..	Large quantity	Starfish-remains.
12	*Limbriconereis sphoerocephala*	..	Large quantity	..
13	..	..	..	Starfish-remains.
14	..	..	In intestine ..	..
15	*Glycera ovigera, Limbriconereis sphoerocephala*	In intestine	In intestine ..	..
16	*Limbriconereis sphoerocephala*	Remains ..	Quantity ..	..
17	..	Remains ..	In intestine ..	..
18	..	..	In intestine ..	..
19	..	..	..	Gasteropod without shell.
20	..	Remains ..	Quantity ..	..

* G. M. THOMSON, Notes on Sea-fishes, *Trans. N.Z. Inst.*, vol. 24, p. 206.
†G. M. THOMSON and T. ANDERTON, History of Portobello Marine Fish-hatchery, *Board of Science and Art Bull. No. 2*, p. 67.

From the above data it may be concluded that the tarakihi (*Dactylopagrus macropterus*) feeds on the sand formations of the bottom. Out of twenty stomachs examined, fifteen contained algae, and this comprised the major portion of all the material. Less than half the stomachs examined contained worms or spatangoid sea-urchin. G. M. Thomson (*loc. cit.*) has recorded the following foods: shell-fish, fish, seaweed, Crustacea, squids, and sand-worms.

LATRIDOPSIS CILIARIS (*Forster*): MOKI.

Trawled in Palliser Bay, April, 1922.

	Worms.*	Algae.	Crabs.	Amphipods.	Other Material.
1	*Potamilla laciniosa*	..	In intestine	..	Sand and mud in intestine.
2	*P. lac.*	..	..	..	Sand in intestine.
3	*P. lac.*	..	..	..	*Mactra scalpellum.*
4	..	Quantity	..	..	Sand and gravel; diatoms.
5	..	Quantity	..	..	Sand and gravel.
6	*P. lac.*	..	..	One ..	Odd pieces shell; sand and mud.
7	*Owenia fusiformis*, *P. lac.* ..	..	..	..	Brittle-star remains; sand and mud.
8	*O. fus.*, *P. lac.*, *Travisia oleus*	..	Several ..	Two, and remains	Starfish; isopod.
9	*O. fus.*, *P. lac.* ..	Quantity	..	..	Sand and gravel.
10	*P. lac.* ..	..	..	..	Sand and mud.
11	*O. fus.*, *P. lac.* ..	Small quantity	..	..	Sea-mouse; sand and mud.
12	Traces worm-cases	..	Remains ..	Two ..	Sand and mud.
13	Tubes *P. lac.* ..	..	..	..	Sand and mud.
14	Traces worm-cases	Quantities	Remains ..	..	Sand and mud.
15	*O. fus.*, *P. lac.* ..	..	..	..	Sand and mud.
16	Sand-tubes *P. lac.*	Quantity	..	Several	..
17	Traces worm-cases	Quantity	..	..	Sand and mud.
18	..	Large quantity	..	..	*M. scalpellum*; sand and mud.
19	..	..	..	..	Sea-mouse; sand and mud.
20	*P. lac.*	Small quantity	Remains ..	..	Diatoms and sand.
21	..	Small quantity	..	Remains	Sand and mud.
22	*O. fus.*, ampharelid polychaetes, *Echiurus novae-zealandiae? E. unicinatus*	..	..	..	Isopods.
23	Ampharelid polychaetes	Quantity	..	..	*M. scalpellum.*
24	*P. lac.*, *T. oleus*...	..	..	One ..	Sea-mouse; isopods; *Psamnobia lineolata.*
25	..	..	Remains ..	..	Sea-mouse.

* *Echiurus novae-zealandiae; E. uncinatus; Owenia fusiformis; Potamilla laciniosa* (with sand-tubes); *Travisia oleus.*

Twenty out of twenty-five stomachs contained worms or worm-remains. Dr. Benham, noting the abundance of *P. laciniosa* on the floor of Palliser Bay, writes: "There seem to be great forests of them in that locality." About 300 sand tube-worms and ampharelid polychaetes were taken from the twenty stomachs, 145 of the latter being from stomach No. 22 alone.

As most of the fish were trawled at the same time as the tarakihi, it may be inferred that at this season the moki frequents parts of the sea-floor covered with the sand or mud most suitable for the growth and development of the various tube-worms which constitute the principal food.

JORDANIDIA SOLANDRI (*Cuv. and Val.*): NEW ZEALAND HAKE.

Trawled in Cook Strait, April, 1922.

The whole of the stomachs examined, excepting one, contained remains of young *Macruronus novae-zelandiae* in varying numbers, the one exception containing numbers of worms, probably parasitic (? *Ascaris* sp.), and one contained also a piece of bivalve shell. In Hawke's Bay this fish has been found to be a voracious fish-feeder,* inhabiting water of about 20 fathoms. Out of twenty stomachs about sixty-nine examples of *Macruronus novae-zelandiae* were extracted. Other food appears to be negligible, and the above records show how great the numbers of the young of *Macruronus novae-zelandiae* consumed during this season must have been.

CHELIDONICHTHYS KUMU (*Lesson and Garnot*) AND LEPIDOTRIGLA BRACHYOPTERA (*Hutton*): GURNARD.

Trawled in Hawke Bay, April, 1922.

No.	Amphipods.	Crabs.	Shrimps.	Sea-mice.	Other Material.
1	*Ampelisca* sp. ..	Seven ..	*Leander* sp. ..	..	Several isopods.
2	..	*Hemiplax* sp.	..	..	..
3	*Ampelisca* sp. ..	One ..	..	Six ..	..
4	..	*Hemiplax* sp.	..	..	..
5	One	..	..	One ..	..
6	..	..	Fragments ..	..	..
7	Two	*Hemiplax* sp.	..	..	..
8	..	*Hemiplax* sp.	.	Six ..	..
9	(Stomach empty.)				
10	Remains ..	..	..	..	..
11	Remains ..	..	..	Six ..	..
12	..	..	..	..	Traces of black mud and sand.
13	Several ..	..	*Squilla armata*	..	Pieces of shell; sand and black mud.
14	Remains ..	..	*Leander* sp. ..	One ..	Pieces of shell; isopod-remains.
15	..	..	..	One ..	Pieces of shell.
16	..	One ..	Remains ..	Two..	..
17	..	..	..	One...	Copepod-remains.
18	Remains ..	..	*S. armata* ..	Three	..
19	..	..	Remains ..	Two..	..
20	..	..	..	..	Sand and mud.
21	Two	..	One	..	..

I believe most of the stomachs examined to be those of *Chelidonichthys kumu*, though in some instances I was unable to examine the fishes from which viscera had been saved by fishermen. *Chelidonichthys kumu* has been regarded by some to be a night-feeding species, but, though I have occasionally found large numbers trawled at night, this is by no means a certain indication. The food indicates a wider range of ocean locality than that of most fishes, food from ocean-floor and mid-waters appearing to be equally mixed. Out of twenty-one stomachs examined, nine contained amphipods or amphipod-remains (*Ampelisca* sp.) in considerable quantities. Unfortunately, the condition of material prevented determination of the species in this as in many other instances. Five stomachs contained

* W. J. PHILLIPPS, Edible Fishes of Wellington, *N.Z. Jour. Sci. & Tech.*, vol. 1, p. 269, 1918.

remains of seventeen crabs (*Hemiplax* sp.), eleven contained twenty-four sea-mice, and six contained shrimp-remains.

Thyrsites atun (*Euphrasen*): Barracouta.

Trawled in Palliser Bay, March–April, 1922.

Of twelve stomachs examined, eight contained young *Macruronus novae-zelandiae* or their remains, one containing in addition several isopods, another several shrimps (*Euphausia* sp.); of the others, one contained squid-remains, one copepod-remains, and another sea-mice (*Aphrodite* sp.).

Macruronus novae-zelandiae (*Hector*): Whiptail.

Trawled in Cook Strait, March, 1922.

Four of the five stomachs examined contained young *Macruronus novae-zelandiae*; the fifth contained small fish-remains (*Clupea* sp. ?).

Adults averaging 18 in. in length were trawled in 30 fathoms and brought into market on at least two occasions during March, 1922, being sold as whiptail. I have since been informed that small quantities of this fish appear in the market every few years. This species was feeding on its own kind, but the record is not sufficient to justify any conclusion; possibly no other food-supply in the shape of young fish was available.

Physiculus bachus (*Forster*): Red Cod.

Trawled in Cook Strait, March, 1922.

(1.) One fish (*Scorpaena cardinalis*); one young of megrim (*Caulopsetta scapha*); considerable number of partially digested worms. (2.) Three half-grown *Macruronus novae-zelandiae*.

Pagrosomus auratus (*Forster*): Snapper.

Trawled in Hawke Bay, April, 1922.

(1.) A few shells (*Verconella nodosa*) in stomach; thirty-two young of *Verconella nodosa*; several *Verconella valedicta*; and two *Euthria* in intestine. (2.) Remains of octopus only.

Genypterus blacodes (*Bloch and Schn.*): Ling.

Secured in Cook Strait in 150 fathoms, April and May, 1922.

Of the six stomachs examined, three contained remains of *Macruronus novae-zelandiae* two contained fish-bones, and one was empty. It is probable that in rising to the surface much of the food of the ling is ejected from the stomach. Practically all stomachs of ling were much infected with parasitic worms. Two contained the cestode worm *Bothriocephalus* sp., or some subgenus. All contained nematodes which appeared to be a species of *Ascaris*. Three had the intestine infected with a species of *Taenia*, which in one case was over 3 ft. long.

Partly digested material is very difficult to handle and more difficult to identify, yet here and there one comes across startling evidences, which may not otherwise be secured, of the occurrence of individual species in unprecedented numbers in certain localities. The two most striking instances noted here are the enormous shoals of *Macruronus novae-zelandiae*

in Cook Strait during the season when most of these fish were trawled, and the great forests of *Potamilla laciniosa* which cover the floor of at least part of Palliser Bay in April. The record of such facts amply justifies time expended on this research.

Among material supplied, Dr. Benham was fortunate in finding one polychaete apparently new to New Zealand, and no doubt many new species of the future will be brought to light by similar methods of research.

New or Rare Fishes of New Zealand.

By W. J. PHILLIPPS, F.L.S.

[*Read before the Wellington Philosophical Society, 28th October, 1924; received by Editor, 15th November, 1924; issued separately, 26th April, 1926.*]

Plates 87–92.

Family CARCHARINIDAE.

Genus PRIONACE Cantor.

Prionace glaucum (Rondelet).

Galeus glaucus Rondelet, 1554, *Pisc.*, p. 378.
Carcharias glaucus Cuvier, *Reg. Anim.*, vol. 2, p. 126, 1817: Yarrell, *Brit. Fishes*, vol. 2, p. 381, 1836: Day, *Brit. Fishes*, vol. 2, p. 289, pl. 152, 1836: Guenther, *Fische Suedsee*, vol. 3, p. 479, 1910.
Carcharinus glaucus Jordan and Gilbert, *Bull. 16 U.S. Nat. Mus.*, p. 22, 1883.
Prionace glauca Jordan and Evermann, *Bull. 47 U.S. Nat. Mus.*, p. 33, pl. 4, fig. 16, 1896; *Bull. U.S. Fish. Com.*, vol. 23, p. 37, fig. 3, 1905: Snyder, *Bull. U.S. Fish. Com.*, vol. 22, p. 515, 1904: Jordan and Fowler, *Proc. U.S. Nat. Mus.*, p. 26, p. 613, 1903: Jordan, Tanaka, and Snyder, *Jour. Roy. Coll. Sci. Tokyo*, vol. 33, p. 13, fig. 5, 1913: McCulloch, *Check-list Fish. N.S. Wales*, p. 6, pl. 1, 1921: Waite, *Rec. South Aust. Mus.*, vol. 2, p. 12, fig. 10 (*glaucum*), 1921: Phillipps, *N.Z. Jour. Sci. & Tech.*, vol. 6, p. 262, fig. 5, 1924.
Galeus glaucus Garman, *Mem. Mus. Comp. Zool. Harvard*, vol. 36, p. 145, pl. 3, figs. 1–3, 1913.

A badly stuffed shark in the Dominion Museum, previously labelled "*Carcharinus brachyurus*, Lyall Bay, Wellington," is referable to this species. Owing to the poorness of the example, my figure of the species (Phillipps, *loc. cit.*, 1924) was not a good one. The mouth is not as there represented, and little idea of the long sweeping pectoral can be gained from the figure. Actually the pectoral is almost equal to the distance from its origin to tip of snout. Such is the case in no other shark, and this is apparently all that is required for its identification.

A further distinction, which possibly may not be so important, is that shown in the relative heights of dorsals in *Prionace* and *Carcharinus*, the two Australasian genera, so closely related on account of the absence of spiracles in both. For example, in the figure of *P. glauca* submitted by Jordan, Tanaka, and Snyder (*loc. cit.*) we find height of first dorsal to be over 7½ times length to c.p. Measuring from figures, we find all available representations of *Prionace glauca* have the relation of the dorsal height to length as above to be 7 to 7¾, while numerous figures of species of *Carcharinus* gave 5·3 to 6 for same relationship. Mr. Gilbert Archey found the relation of height of dorsal to length in a Canterbury Museum example from a New Zealand locality to be 7; but in the Dominion Museum specimen this relationship is over 7½.

Family ISURIDAE.

Genus Isurus Rafinesque.

Isurus glaucus (Mueller and Henle). (Plate 87.)

Oxyrhina glauca Mueller and Henle, *Plagiost.*, p. 69, pl. 29. 1838: Schlegel, *Jap. Pisces*, p. 302, 1850: Dumeril, *Elasm.*, p. 409, 1865.
Isuropsis glaucus Gill, *Ann. N.Y. Lyc.*, vol. 7, p. 398, 409 (name), 1861: Jordan and Fowler, *Proc. U.S. Nat. Mus.*, vol. 26, p. 623, 1903: Jordan, Tanaka, and Snyder, *Jour. Roy. Coll. Sci. Tokyo*, vol. 33, p. 16, No. 38, 1913.
Lamna glauca Guenther, *Cat. Fish. Brit. Mus.*, vol. 8, p. 391, 1870; *Fische Suedsee*, vol. 3, p. 484, 1910.
Lamna spallanzanii Day, *Fishes of India*, p. 722, pl. 186, fig. 2, 1878.
Isurus glaucus Jordan and Evermann, *Bull. U.S. Fish. Com.*, vol. 23, pt. 1, p. 43, 1903: Garmen, *Mem. Mus. Comp. Zool. Harvard*, vol. 36, p. 38, 1913: McCulloch, *Check-list Fish. N.S. Wales*, p. 8, pl. 2, 1921: Waite, *Rec. South Aust. Mus.*, vol. 2, p. 21, fig. 27, 1921: Phillipps, *N.Z. Jour. Sci. & Tech.*, vol. 6, p. 268, 1924.

Body rounded, tapering anteriorly and posteriorly from under first dorsal. Head ¼ total length. Depth at pectoral is contained 7·61, or under first dorsal 6·19, in total length. Eye to snout 3·3 in head, which is 4 in total length. Snout to origin of dorsal is 2·47, and snout to origin of pectoral 4·13, in total length. Snout to first gill-opening equals distance from origin of ventral to origin of anal, or five times pre-oral length. Thirty-three myomeres on side of body between posterior margin of first dorsal and commencement of second dorsal. Gill-slits regularly decreasing in size posteriorly, the last being in advance of pectoral. First gill-opening advancing considerably towards its fellow on the ventral surface. Lateral line rises in a distinct ridge on caudal peduncle near dorsal surface. A more or less vertical ridge defines base of caudal, and a ridge at right angles to it separates caudal lobes.

Fins: Pectoral 1·3 in head, its base being 1·38 in eye to snout. Height or dorsal about 2 in head and origin nearer origin of pectoral than origin of ventral. Second dorsal slightly smaller than and rises in advance of anal. Upper caudal lobe more than ¼ lower caudal lobe; secondary lobe of upper caudal lobe 5·3 times upper caudal lobe. Lower caudal lobe 1·27 in upper caudal lobe.

Teeth: There are 4 teeth in front on each side large and conspicuous, while the third tooth on each side is considerably smaller. Jordan and Evermann (*Bull. U.S. Nat. Mus.*, vol. 47, vol. 1, p. 48, 1896) have found similar conditions in *Isurus dekayi* (Gill) taken from Cape Cod to West Indies. As in the other American species, *oxyrhynchus*, our species has 13 to 14 rows of teeth. Teeth at sides more triangular, and those in front narrow, long, flexuous, and point either directly down throat or towards roof of mouth. No basal cusps.

Garmen (*loc. cit.*) recognizes six species of *Isurus*, one of which, *Isurus glaucus*, from Japan and the North Pacific, has recently been included in the New South Wales list by McCulloch (*loc. cit.*). Waite (*loc. cit.*) has included the same species from South Australia; in this we note several characters which would appear to distinguish it from Mueller and Henle's figure. From available descriptive matter it appears possible that the original figure they submitted was not a good drawing of the species; for certainly, if Mueller and Henle's figure is correct, both the New Zealand species and that figured from South Australia are new to science. This is improbable.

Mueller and Henle showed the relation of the lower to the upper lobe of caudal to be 1·44. In Waite's figure it is 1·36, and in the New Zealand examples 1·27. The New Zealand examples have origin of dorsal distinctly behind posterior pectoral margin, as is the case in the type, while Waite's figure shows the dorsal rising over hinder margin of pectoral. Such discrepencies may be due to faulty taxidermy where museum examples have been examined. A twist in the lower caudal fin to represent swimming motion might easily be responsible for an artist failing to show the comparative size of lower caudal lobe.

Isurus glaucus is perhaps one of the world's most famous sporting fishes. It abounds in considerable numbers around the northern part of New Zealand, and anglers from all parts of the globe annually journey to Bay of Islands to capture it. Its average weight appears to be between 220 lb. and 330 lb., and it is to be secured throughout the summer off most of our northern rocky coast-line. This species is the " mako " of the Maori, which name it still retains.

Family GALAXIIDAE.

Genus GALAXIAS Cuvier.

Galaxias burrowsius n. sp. (Plate 88.)

D. 11 ; C. 14 (true rays) ; A. 12 ; V. 5 ; P. 11. Br. 7.

Length of head is contained approximately 5 times in length to caudal peduncle, while depth of body is contained about 9 times in same. Diameter of eye is 1·7 in anterior margin of eye to snout. Lower jaw longest, maxillary extending to vertical under anterior margin of eye. About 51 myomeres visible on side of body.

Body not greatly compressed. Top of head and body somewhat flattened. Behind nostrils on each side are a number of pores of two sizes. These are situated on top of head in neighbourhood of each eye, and encircle preopercular region to mandibles. Nostrils placed one on each side in front of eye at distance equal to diameter of eye. Eyes moderate. Two pyloric appendages.

Fins: Ventral atrophid with 5 rays. Caudal rounded. Pectoral extends back to ¼ of distance from base to base of ventral; ventral reaches back less than ⅓ distance from its base to base of anal. Origin of dorsal far back above anal. Dorsal not triangular, but elongated as in *Neochanna*.

Teeth: Present only on premaxillaries, lower jaw, and tongue, there being distinct enlarged lateral canines in lower jaw, and 3 to 4 series of large curved teeth on tongue.

Colour: General ground-colour of body dark green, with darker markings on side which tend to arrange on lines of myomeres. A general yellowish tinge is present around most markings, and on head and tail. Caudal with its large procurrent attachment is of a deep-yellow colour marked with brown spots. Dorsal and anal fins are light brown, the pelvic or ventral white with red at base, and the pectoral brown. The operculum is green and under-surface of body white. Lateral line distinctly marked by means of a row of minute golden dots.

Type: In the Dominion Museum. Total length, 131·5 mm.

Affinities of *Galaxias burrowsius*: General shape of body and disposition of dorsal, caudal, and anal fins altogether show a strong superficial resemblance to *Neochanna*; but the presence of a ventral fin with 5 rays and dorsal with 11 rays indicates a close relationship to *Galaxias*. Specimens of *Galaxias brevipinnis* and *Galaxias lynx* in the Dominion Museum show a

like point of origin for the ventral. All members of the genus *Galaxias* so far recognized from New Zealand have 7 rays in the ventral, and in three species alone out of twenty-six recognized members of this genus (Regan, *Proc. Zool. Soc. Lond.*, vol. 2, pt. 2, pp. 363–83, 1906) the number is reduced to 6. These are—one species, *dissimilis*, the type of which is in the Australian Museum, and also *zebratus* and *punctifer*, the only two species known from South Africa. In *Galaxias burrowsius* ventral has undergone a remarkable decrease in size and extends less than ⅓ the distance from base to origin of anal, while in all other New Zealand species of *Galaxias* ventral extends ½ to over ¾ the same distance.

Galaxias burrowsius is undoubtedly a degenerate form of *Galaxias*, and is to some extent a connecting-link between *Galaxias* and *Neochanna*. It is known only from one locality, West Oxford, in the South Island of New Zealand. Two examples were secured by Mr. A. Burrows and forwarded to the Dominion Museum. They were packed alive in a tin box together with a quantity of damp earth, sent by parcel-post on a journey lasting over thirty hours, and arrived alive and extremely active.

Of this species Mr. Burrows writes as follows: "A creek near my house is dry for a good part of the summer, but every spring it has small fish in it from 4 in. to 6 in. in length. They swim in small shoals, and I caught some and placed them in a waterhole. The waterhole became dry, and no fish were to be seen; but on digging the bank down I found in it holes shaped like a coconut in which the fish hid, each with a small entrance. The holes were very smooth inside, and could hold water for a long time if the entrance was carefully closed from the inside."

Family GADIDAE.

Genus Lotella Kaup.

Lotella rhacinus (Forster). (Plate 89.)

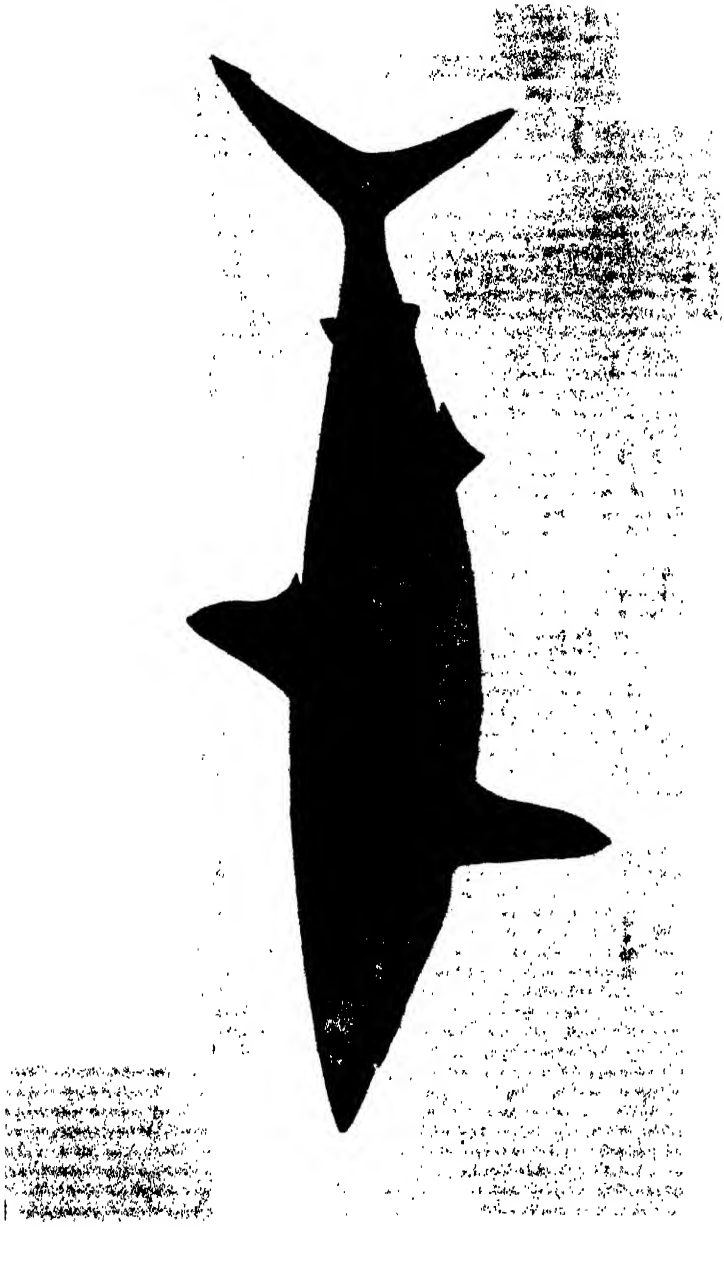
Gadum rhacinum Forster, in Bloch and Schneider, *Syst. Ichth.*, p. 56, 1801.
Lota rhacina Richardson, in Dieffenbach, *Travels in N.Z.*, vol. 2, p. 222, 1843.
Gadus rhacinus Forster, *Descr. Anim.*, p. 304, 1844.
Lotella rhacinus Guenther, *Cat. Fish. Brit. Mus.*, vol. 4, p. 347, 1862: Hector, *Cat. Col. Mus.*, p. 80, 1870: Hutton, *Cat. N.Z. Fish.*, p. 46, 1872; Hector, in Hutton, *Cat. Fish. N.Z.*, p. 116, 1872; Hutton, *Trans. N.Z. Inst.*, vol. 5, p. 266, 1873; *ibid.*, *Trans. N.Z. Inst.*, vol. 6, opp. p. 104, pl. 18, fig. 74, 1874; *ibid.*, *Trans. N.Z. Inst.*, vol. 22, p. 282, 1890.
Physiculus rhacinus Hutton, *Index Faunae N.Z.*, p. 48, 1904: Waite, *Rec. Cant. Mus.*, vol. 1, p. 18, 1907; *ibid.*, *Rec. Cant. Mus.*, vol. 1, p. 318, 1912.

D. 5+58; C. 26; A. 52; V. 2+7; P. 23. Br. 7. L. lat. 120.

Body stout and elongate, compressed laterally, compression being greatest from second dorsal to anal and least beneath first dorsal in region of pectoral and immediately below it. Depth at vent 3·4, and length of head nearly 4 in length to caudal peduncle.

Head: Interorbital space raised just above eye on each side, with a tendency to become concave on top in specimen examined. Eye large, deeply set, its diameter being contained 5 times in length of head. Upper jaw longer; maxillary extends backwards to vertical under pupil of eye. Mandibular barbel greater than ½ length of pectoral.

Teeth: 15 large pointed conical teeth irregularly placed on outer margin of each side of lower jaw; 12 teeth on outer margin of each side of upper jaw, similar save that they are smaller amd more irregular. Villiform band of teeth immediately inside outer row in upper jaw, while small scattered teeth in bands occupy the same position in lower jaw. Oval patch of 12 rows of small teeth present on head of vomer.



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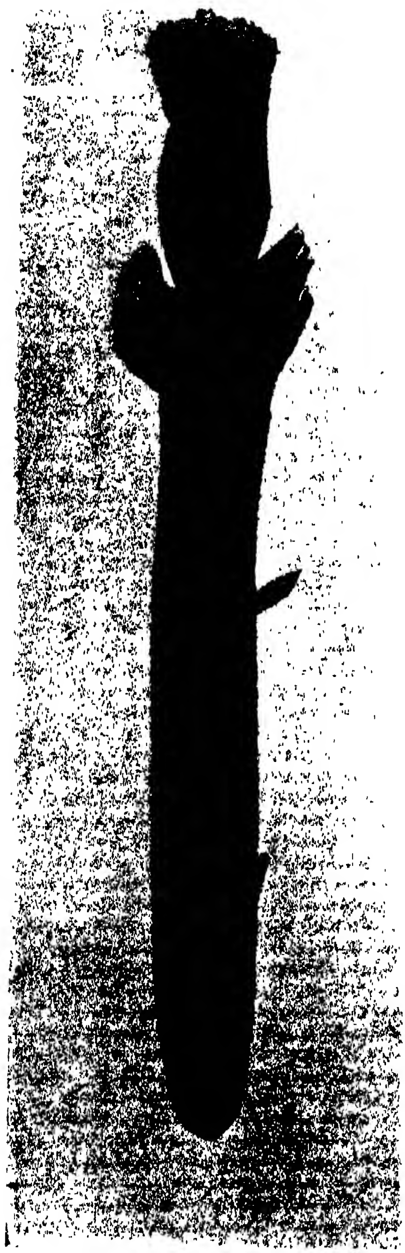

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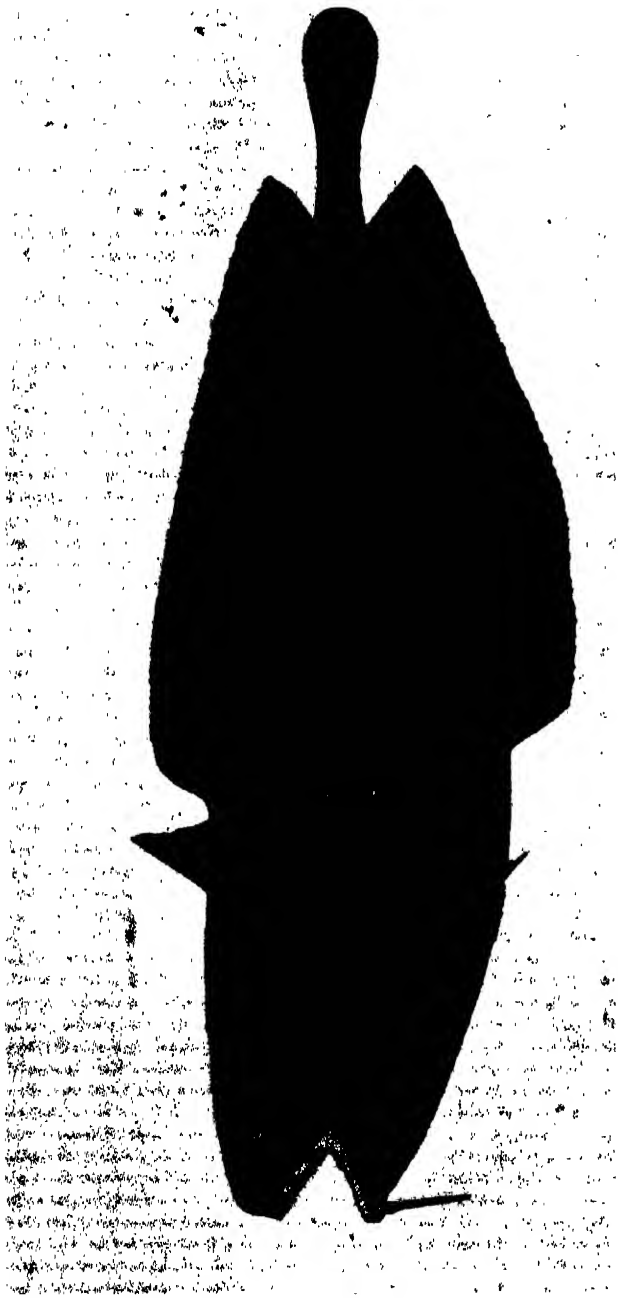

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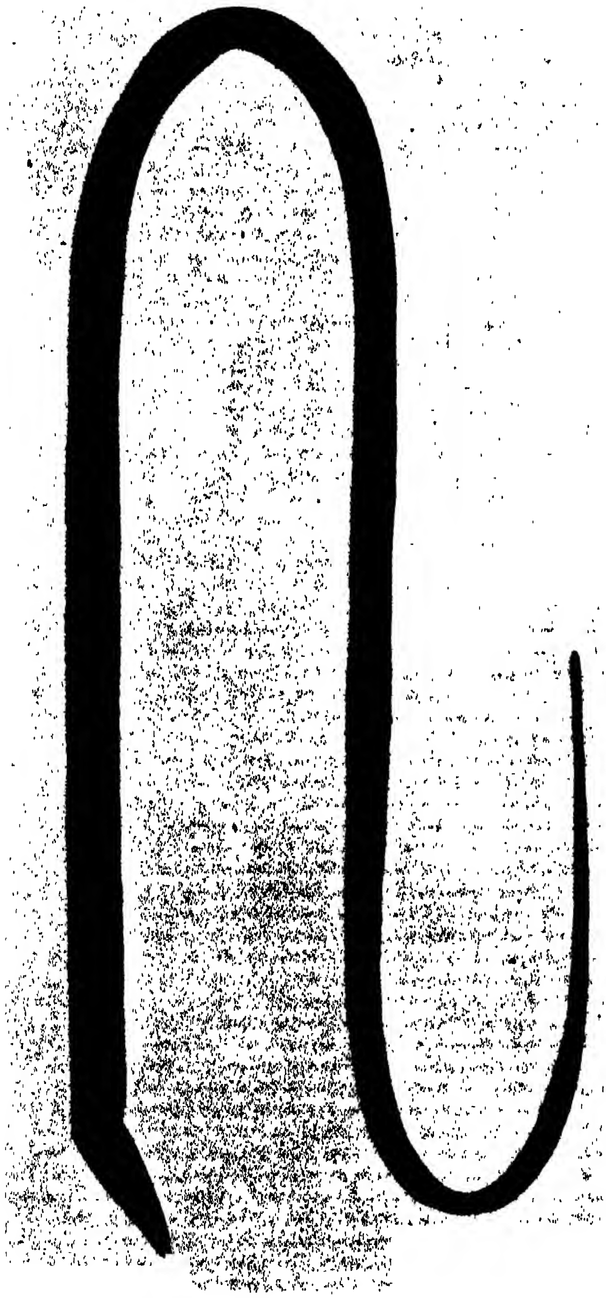
Lotell



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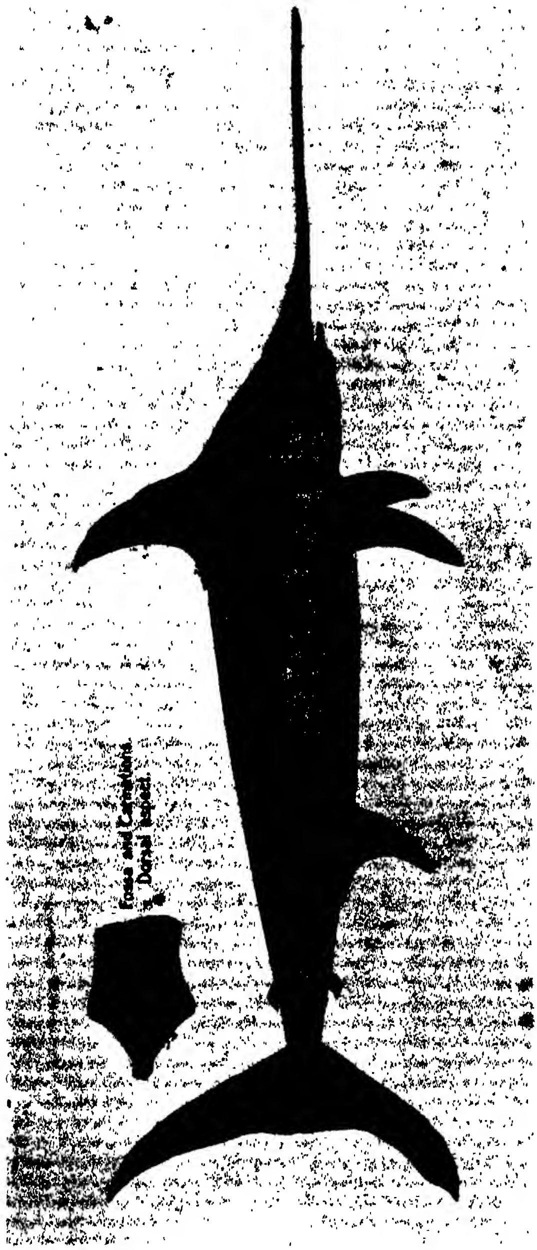

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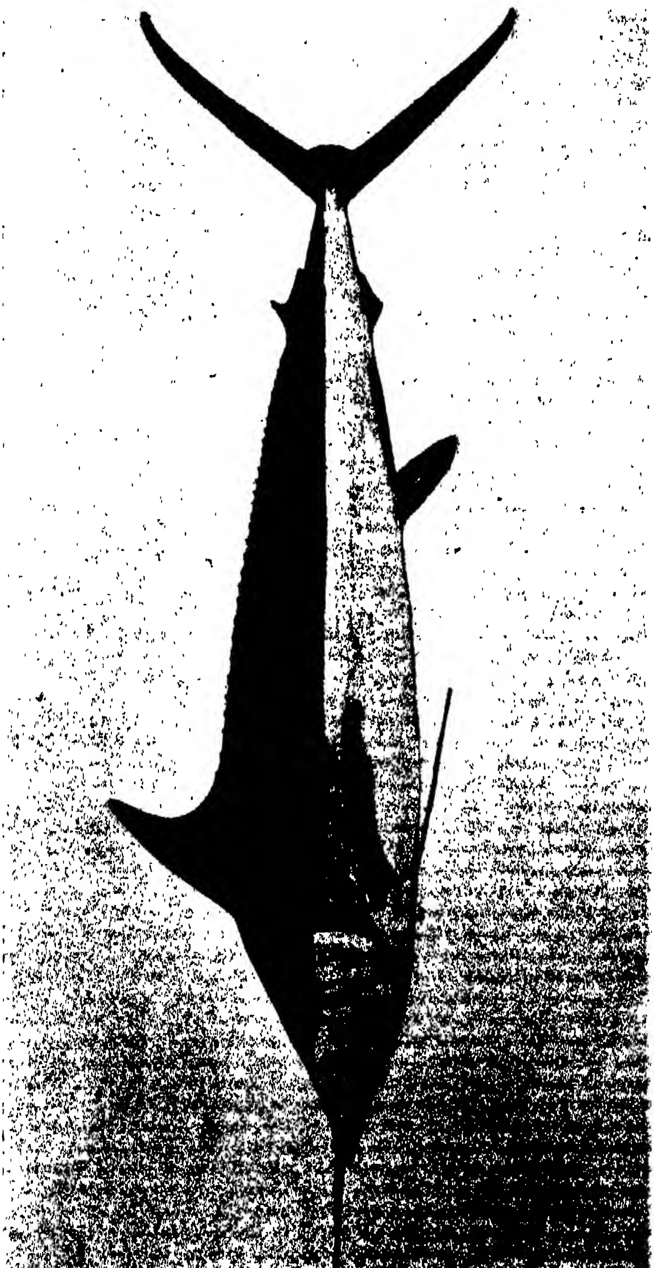

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Fins: The first dorsal commences over origin of pectoral, being placed relatively farther back than in Australian species. Ventral commences a little farther forward in reference to pectoral than in Australian species. Second outer filamentous ventral ray reaches nearly ⅗ distance from base of ventral to vent. Vent situated slightly less than ⅓ of total length of fish from snout to end of tail. Anal commences 10 mm. behind vent. Caudal small and rounded.

Colour: Uniform dark red. A dark line runs from upper margin of operculum to dorsal surface. Other dark markings, more or less distinct, are apparent on head, running parallel to branchiostegal rays. Below fins colour lightens to a pale reddish-yellow. Fins uniformly dark.

The following key will serve to differentiate the New Zealand and Australian species of *Lotella* :—

Depth at vent 3·4 and length of head nearly 4 in length to caudal peduncle .. .. *rhacinus.*
Depth at vent nearly 4 and length of head 4·5 or over in length to caudal peduncle .. .. *callarias.*
Callarias has a longer maxillary bone than *rhacinus.*

Hutton (*loc. cit.*) called this species "hake," a term used to refer to *Merluccius vulgaris* in the North Sea. If we are to continue to apply English names to like New Zealand species, *Merluccius gayi* has prior right to the name "hake"; but, unfortunately, *Jordanidia solandri* is in Blenheim, Nelson, Picton, Wellington, and Napier caught and sold as "hake." This I have verified.

Lotella rhacinus is not uncommon in Cloudy Bay, and during 1924 small numbers were sold in Wellington as "Cloudy Bay cod" and "rock-cod." Working on the principle of applying English names to like and related species in our waters, *Lotella rhacinus* might rightly be described as a haddock or a cod. The first specimen which came under my notice was secured by the late Dr. Moorhouse (of Christchurch) off Cape Brett, and presented to the Dominion Museum. This example is here figured, and is stouter than most Wellington specimens.

The following key will serve to differentiate the two allied genera, *Physiculus* and *Lotella* :—

A row of strong large teeth with bands of small ones; scales very small .. .. *Lotella.*
Teeth subequal in size, in bands, scales large .. .. .. *Physiculus.*

I have to thank Mr. A. R. McCulloch, of the Australian Museum, for comparing a specimen from New Zealand with the Australian examples.

Family AOTEAIDAE new.

AOTEA n. gen.

Body naked, extremely elongate, cylindrical, not appreciably compressed except in caudal region, tapering only in posterior quarter of length. Body and head covered with a semitransparent skin, which peels off on being handled. Lips well developed; snout acute and compressed, overlapping mandible, mouth being underneath. Lateral line present. Fins absent. A semitransparent portion of back towards tail may represent the dorsal fold of certain Synbranchidae, or may be caused by shrinkage. Minute teeth present in several series on palatines and vomer extending to intermaxillaries. Mandibular teeth in single series. All teeth minute and approximately the same size, though those on symphysis appear stronger.

Aotea acus n. sp. (Plate 90.)

Length of head approximately 24 and depth behind head 50 in total length. Eye 12 in length of head. A minute posterior nostril situated on each side of head about diameter of eye in front of posterior margin in line with centre of pupil. Upper maxilla overlaps mandible by a distance equal to diameter of eye. Angle of jaws reaches back to distinctly behind posterior margin of eye. Eye to snout equals depth of body behind head. Snout not anteriorly rounded as in *Synbranchus*.

Owing to abrasions and swellings, apparently caused by parasites, the anus has been obliterated. Species is unfortunately not in a fit state for dissection, but position of vent appears to be under one of the numerous swellings on the ventral surface in anterior portion of body. A hard folded portion beneath body posterior to head apparently indicates gill-openings, which are similarly placed in *Synbranchus*. Along parts of anterior body-wall segmentation is clearly visible.

Affinities of *Aotea acus*: *Aotea acus* differs from all other genera of the suborder Synbranchiformes in the possession of vomerine teeth, and also, as far as can be learned from available literature, in the extremely elongate body. Guenther (*Cat. Fish. Brit. Mus.*, vol. 8, p. 12, 1870) has divided what was then regarded as the family Symbranchidae* into the following three groups—(*a*) Amphipnoina, (*b*) Symbranchina, (*c*) Chilobranchina—of which the first two have vent in posterior half of length, while the last has vent in anterior half; but all Chilobranchina known to Guenther were without vomerine teeth.

Weber and Beaufort (*Fish. Indo-Aust. Archip.*, vol. 3, p. 411, 1916) discuss the order Synbranchoidea, and give a key to the three genera of Synbranchoidea. It would appear that *Aotea acus* shows certain affinities to *Monopterus albus*, common in the fresh waters of Sumatra, Borneo, China, and Japan; but its serpent-like head, attenuate body, and vomerine teeth indicate otherwise. The New Zealand species appears to show considerable differentiation of arrangement of frontal, parietal, and supra-occipital bones of the skull; but without injury to the type it is impossible to determine how far bones have been modified.

Regarding the Synbranchiformes, Goodrich (*Treatise on Zoology*, vol. 9, p. 408, 1909) writes: "A small group of very highly specialized fish whose affinities cannot yet be determined. They have a superficial resemblance to the eels, from which they differ in many important osteological characters, and in the possession of closed ovisacs. The air-bladder is absent. The skull is like that of the Clupeiformes; the parietals meet, but the maxillae are almost excluded from the margin of the mouth. The group is unknown in a fossil state."

Aotea acus is related to the order Carenchelyi, or long-necked eels, in its slender body and serpent head (Jordan and Evermann, *Bull. U.S. Nat. Mus.*, vol. 47, p. 343, 1896). This order is represented by a single species taken in the Gulf Stream at 1,022 fathoms; but it differs from the New Zealand species chiefly in the presence of fins. The Synbranchiformes are represented in Australia by the family Cheilobranchidae, of which two small species, 2 in. to 4 in. long, are common in coastal rock-pools and inshore waters (McCulloch, *Check-list Fish. N.S.W.*, p. 22, Nos. 76A and 76B, 1920).

Type: The type was taken from the stomach of a snapper (*Pagrosomus auratus*) secured in Cook Strait, and forwarded to the Dominion Museum by Mr. H. P. Washbourn, Nelson. It is assumed that the species is marine,

* Generally wrongly spelt "Symbranchidae" instead of "Synbranchidae."

and it is possibly an inhabitant of deep water which had died or left its abode owing to disease.

Family GIRELLIDAE.

Genus GIRELLA Gray.

Girella cyanea Macleay.

Girella cyanea Macleay, *Proc. Linn. Soc. N.S. Wales*, vol. 5, p. 409, 1881: Ogilby, *Proc. Zool. Soc. Lond.*, p. 394, 1887: Waite, *Rec. Aust. Mus.*, vol. 5, p. 167, pl. 20, 1904: Roughley, *Fish. Australia*, p. 54, pl. 13, 1916: Phillipps, *N.Z. Jour. Sci. & Tech.*, vol. 4, p. 116, 1921.

Hitherto known from waters of New South Wales, the Kermadec and Lord Howe Islands, I have recently recorded *Girella cyanea* from Hauraki Gulf, where it appears to be caught only by the Maori. It is not common, and is rarely seen south of Whangarei. Structurally it resembles *Girella tricuspidata*, but differs chiefly in having a deeper body, smaller scales, and outer teeth in single rows. Messrs. W. R. B. Oliver and H. Hamilton, of the Dominion Museum, have recently taken *G. cyanea* off Poor Knights Islands.

Family AGROSTICHTHYIDAE.

Genus AGROSTICHTHYS Phillipps.

Agrostichthys parkeri (Benham).

Regalecus parkeri Benham, *Trans. N.Z. Inst.*, vol. 36, p. 198, pl. 9, 1904: Phillipps, *N.Z. Jour. Sci. & Tech.*, vol. 6, p. 232, 1923.
Agrostichthys parkeri Phillipps, *Proc. Zool. Soc. Lond.*, pt. 2, p. 540, figs. 1, 2, 1924.

This species, which I have made the type of a new genus, is of peculiar interest in that its general outline of body agrees with the Regalecidae, while the shape of the head and disposition of the teeth show considerable affinity to the Trachypteridae. It differs from each, however, in the enormous extent to which the body of the adult is elongated, and also in the long maxillary plate.

Suborder XIPHIIFORMES.

Ventral fins absent; mandible less than ⅓ maxillary ..	Fam. XIPHIIDAE.
Ventral fins present; mandible ⅓ or more than ⅓ maxillary	Fam. ISTIOPHORIDAE.

Family XIPHIIDAE.

Genus XIPHIAS Linnaeus.

Xiphias gladius Linnaeus. (Plate 91.)

Xiphias gladius Linnaeus, *Syst. Nat.*, ed. 10, p. 248, 1758: Guenther, *Cat. Fish. Brit. Mus.*, p. 511, 1860: Hutton, *Trans. N.Z. Inst.*, vol. 22, p. 278, 1890: Jordan and Evermann, *Bull. U.S. Nat. Mus.*, vol. 47, pt. 1, p. 894, 1896; *Bull. U.S. Fish. Com.*, vol. 23, p. 168, fig. 61, 1903: Hutton, *Index Faunae N.Z.*, p. 43, 1904: Waite, *Rec. Cant. Mus.*, vol. 1, p. 25, 1907.
Ziphius gladius Hector, *Trans. N.Z. Inst.*, vol. 7, p. 246, 1875.
Ziphias gladius Cheeseman, *Trans. N.Z. Inst.*, vol. 8, p. 219, 1876.
Xiphius gladius Sherrin, *Fish. N.Z.*, p. 96, 1886.

D. 2+14/3; P. 1+12; A. 1+9/3. Br. 7.

Head approximately 5, depth at opercular edge excluding dorsal sheath nearly 6, and depth at anterior anal 7·73 in length from tip of mandible to tip of caudal. Tip of spear to eye approximately equal to distance between

origin of pectoral and first anal. Mandible pointed and ½ length of head. Eye 6·08 in head. No teeth. Body generally compressed laterally, naked, more or less rough, and compressed dorso-ventrally in region of caudal peduncle. An enlarged keel on each side about middle line on caudal peduncle, which is broader than deep.

Fins: First dorsal commences above gill-openings, falcate, and elevated, rising to a height almost equal to length of head. Second dorsal small, rising well back on dorsal surface and reaching over lateral keel. Length of pectoral approximately equal to depth at opercular margin. First anal sometimes originates at a point a little nearer operculum than tip of caudal. Second anal is in front of second dorsal and about the same size. Ventrals absent. Caudal forked.

Colour: "Upper surface has a general greyish-purple tinge merging to dark grey on dorsal surface. Fins of uniform greyish-green. Under-surface white" (Clarke's drawing). Jordan and Evermann describe the Hawaiian example as follows: "Colour dark metallic-purplish above, dusky below, sword almost black above, below lighter; fins dark, with silvery sheen."

Clarke's drawing of the species, here published for the first time, represents a swordfish having a total length of 11 ft. 9¾ in., washed ashore on Hokitika beach. It appears to agree very well in all essential details with Cuvier's figure of the species, reproduced by Jordan and Evermann (1903, *loc. cit.*). The large fossa shown on the sides of Clarke's example are not shown in figures of this species from the Atlantic, and do not appear in a large stuffed example among the collection of New Zealand fishes in the Dominion Museum. The young of *Xiphias gladius* is known to be possessed of teeth and two connected dorsal fins. Though not common in the Pacific, the species is highly valued as food in southern Europe, and is the object of extensive fisheries in the Atlantic.

Family ISTIOPHORIDAE.

Genus Istiophorus Lacepede.

Istiophorus gladius (Broussonet). (Plate 92.)

Scomber gladius Broussonet, *Mem. Acad. Sci.*, p. 454, pl. 10, 1786.
Istiophorus gladifer Lacepede, *Hist. Nat. Poiss.*, vol. 3, p. 374, 1802.
Histiophorus indicus Cuvier and Valenciennes, *Hist. Nat. Poiss.*, vol. 8, p. 293, pl. 229, 1831: Valenciennes, *Regne Anim. Illustr. Poiss.*, vol. 49, p. 124, pl. 53, fig. 1, 1836.
Histiophorus sp., Knox, *Trans. N.Z. Inst.*, vol. 2, p. 13, pl. 1, 1870.
Histiophorus herschellii Hutton, *Trans. N.Z. Inst.*, vol. 8, p. 216, 1876.
Histiophorus gladius Guenther, *Brit. Mus. Cat. Fish.*, vol. 2, p. 513, 1860: Day, *Fish. India*, pt. 2, p. 198, 1876: Castelnau, *Proc. Linn. Soc. N.S. Wales*, vol. 3, p. 352, 1879: Macleay, *Proc. Linn. Soc. N.S. Wales*, vol. 5, p. 522, 1881: Goode, *Rep. U.S. Fish. Com.*, 1880, p. 309, pl. 8, 1883: Ogilby, *Cat. Fish. N.S. Wales*, p. 25, 1886.
Histiophorus herschellii Hutton, *Cat. Fish. N.Z.*, p. 14, 1872; *Trans. N.Z. Inst.*, vol. 22, p. 278, 1890; *Index Faunae N.Z.*, p. 43, 1904: G. M. Thomson, *Hist. Portobello Fish-hatch.*, p. 79, 1921 (*herschelli*).
Tetrapturus indicus Waite, *Mem. N.S. Wales Nat. Club*, p. 42, 1904; *Rec. Cant. Mus.*, vol. 1, p. 25, 1907.
Istiophorus gladius McCulloch, *Rec. Aust. Mus.*, vol. 13, pt. 4, p. 137, pl 24, 1921.

D. 47+7; A. 9+7; P. 17; V. 2. Br. 7.

Depth under third anterior dorsal ray (excluding dorsal sheath) 1·7 in length of head measured from tip of mandible to opercular margin, or almost

exactly 6 times in length from tip of mandible to highest point on lateral keels at base of caudal. Eye 10 in head. Eye to tip of rostrum approximately equal to length of head. Rostrum straight, broader than deep, covered exteriorly by rough rounded spinulex which continue posteriorly well toward angle of jaw. Mandible pointed in front and extending backwards beyond posterior margin of eye. Nostrils small, situated in front of eyes.

Body compressed, broadest in region of pectoral and thence narrowing backwards. A broad fleshy fold on each side of body on dorsal surface extending backward to commencement of second dorsal, thus forming a sheath to accommodate first dorsal rays. Ventral and anterior anal rays have similar sheaths. Bases of second dorsal and second anal uncovered. Body covered entirely with pointed scales, shortest on dorsal surface and longest on ventral. Caudal peduncle deeper than broad, with two keels on each side forming distinct ridge.

Pectoral relatively longer than in McCulloch's example, reaching from base more than ½ distance to origin of anal, or being longer than depth under anterior dorsal rays. Dorsal commences above operculum, having first two rays short and third longest. Thence rays decrease in size to second dorsal, which consists of 7 rays, the first being longest and others decreasing posteriorly. Caudal slender and much forked, with two raised keels on each side of base. Towards posterior margin of the strong base of caudal lobes are 3 ridges which may be supplementary keels.

Origin of first anal to origin of second anal equals height of dorsal above opercular margin. Second anal is below second dorsal, its first ray being longest and others smaller posteriorly. First anal has third ray longest. Ventral commences a little behind origin of pectoral, and consists of 2 fused rays forming a rod on each side extending backwards as far as pectoral.

Colour: Upper surface dark brown with several curious vertical bands of white, some of which extend from dorsal surface to lateral line. This ground-colour of brownish-black extends forwards to eye and on to rostrum in front and sharply defines the greater part of upper dorsal surface, being posteriorly confined to upper portion of caudal peduncle. Ventral surface white, in marked contrast to dorsal. All fins of a dull reddish-brown. Anterior dorsal is not in this case uniformly black as in McCulloch's description of the young.

Discussion: This species is the common swordfish of Bay of Islands. It is here described from a specimen washed up at Napier and purchased from Messrs. Boyd during 1921. A cast is in the Dominion Museum. As a sporting fish of our northern waters this species has recently risen to fame, and, together with the mako and kingfish, is a favourite with visiting anglers. The young of this species, so well described by McCulloch (*loc. cit.*), apparently differs in two important respects from the New Zealand species—(1) the shorter pectoral, and (2) the incongruous length of the dorsal fin. Of these differences the former is the more important. Possibly much of the dorsal breaks away as the fish grows up; and it can only be assumed that, as the dorsal disappears, the pectoral increases in length and becomes in the adult the long appendage shown in the accompanying plate.

Descriptions of New Zealand Fishes.

By L. T. Griffin, F.Z.S., Assistant Curator, Auckland Museum.

[*Read before the Auckland Institute, 25th November, 1924; received by Editor, 6th September, 1924; issued separately, 26th April, 1926.*]

Plates 93–98.

Family MURAENIDAE.

Genus Gymnothorax Bloch.

Gymnothorax prionodon Ogilby. (Plate 93.)

Gymnothorax prionodon Ogilby, *Proc. Linn. Soc. N.S. Wales*, ser. 2, vol. 9, p. 270, 1895.

Length of head 4 in trunk or $8\frac{3}{4}$ in total. Height of body rather more than 7 in trunk or $1\frac{1}{8}$ in tail. Eye 9 in head or 2 in snout; gill-opening rather more than $\frac{1}{2}$ diameter of eye. Length of anterior nasal tube subequal with width of gill-opening. Snout 5 in head; mouth $2\frac{1}{4}$ in same. Teeth on sides of jaws 14 above, 16 below. Palatine teeth 7; vomerine teeth 3.

Body moderately compressed for three-fourths of length, after which it becomes much compressed to tip of tail. Occipital region elevated, fleshy. Snout convex above, swollen on sides, curved downwards anteriorly. Cleft of mouth extends behind eye. Teeth in jaws uniserial, subtriangular, acute, getting gradually smaller towards the angle. Vomerine teeth (if present) subulate or triangular and depressible. Palatine teeth very small, in a short even row. None of teeth serrated. Tongue immovable. A series of 3 pores on ramus. Posterior nostril an oblong slit surrounded by low rim, placed above anterior quarter of eye. Branchiostegal sac moderately developed. Origin of dorsal fin vertically above gill-opening, the fin is thick and fleshy. Anal fin similar to dorsal, but much lower, less than half height of former, both fins surround tip of tail.

Colour.—The whole fish when alive was a uniform dark brown above, with a greyish shade below from throat to vent. Numerous short wavy transverse streaks black in colour are spread over the whole fish as far as tip of tail, also three distinct longitudinal lines reaching from the branchiostegal sac to tip of tail. Folds of gill-membrane well marked with five or more black zigzag lines. Angle of the mouth black. Cream-coloured spots varying in size cover head, body, and dorsal fin, but no spots are found on anal fin. The spots are largest about centre of fish, smaller on occipital region and sides of head, minute on snout. Anal fin uniform very dark brown.

Described and figured from an adult specimen which is 714 mm. long from snout to tip of tail. The length from tip of snout to vent is 328 mm.; vent to tip of tail, 386 mm.; snout to gill-opening, 82 mm.; greatest height of body, 60 mm.

Variation.—I have received two specimens of this interesting species; the one described was caught at the Mokohinau Islands in April, 1922, and the second one, which is far larger, was taken at the Alderman

Islands in the following August. The total length of the second specimen is 848 mm., and its greatest height 80 mm. There are several other differences, which may be noted here: The vomerine teeth are reduced to 2, placed close together, and close to base of anterior maxillary teeth. They are both triangular in shape, not subulate as in specimen figured. One pore only is found on the ramus, situated nearer angle than middle of jaw. The general colour of the fish and form of spots shows a marked variation, the former being a light-golden brown in life, while the spots vary from single round and oval ones to groups of from 2 to 4 placed in close juxtaposition, the latter being disposed mostly about the middle portion of the body and dorsal fin. The difference in colour, form of spots, and the reduced number of vomerine teeth may be due entirely to age. Mr. A. R. McCulloch, Zoologist to the Australian Museum, in writing me after examining these two eels, says: "The type of the species is a young specimen and has no vomerine teeth, and its maxillary ones are not so uniform as in your larger specimen, but these differ in your two, the vomerine teeth being proportionately smaller in the younger of your specimens. In very young examples I believe you will find the vomerine teeth undeveloped."

Locality. — Mokohinau and Alderman Islands, Auckland Provincial District.

Type in Australian Museum, "believed" to have been taken in Port Jackson Harbour, but has not been recognized from that locality since.

Gymnothorax prasinus Richardson. Green Eel.

> *Muraena prasina* Richardson, *Ichth. Ereb. and Terr.*, p. 93, 1847; *M. krullii* Hector, *Trans. N.Z. Inst.*, vol. 9, p. 468, pl. 8, fig. 107*a*, 1877.

When Hector described and figured this eel as a new species under the name of *M. krullii* he probably overlooked Richardson's description, or for some other reason thought his specimen differed specifically. For some time there has been a doubt as to whether our very common green eel (sometimes called "yellow eel" by local fishermen) should be classed as a new species under Hector's nomenclature; and in order to settle this important matter I forwarded a fine example of the eel to Mr. McCulloch for comparison with the New South Wales species. He now informs me that *G. krullii* is synonymous with their common green eel, *G. parasinus*. He adds that the dentition of this species is very variable, and that he has seen none in which it quite agrees with Richardson's description, but there is no room for doubt as to the identity of the New South Wales species, and that my specimen agrees in all details with Australian specimens of similar size.

Gymnothorax ramosus n. sp. (Plate 94.)

Length of head 8½ in total or 7½ in trunk. Height of body ½ length of head, or rather more than 5 in trunk, or 8 in tail. Eye 10 in head or 2 in snout; gill-opening about as wide as eye. Nasal tube equal to width of eye. Snout 5½ in head; mouth 2½ in same. Teeth on sides of jaws, 14 above, 14 below. Palatine teeth 10; vomerine teeth (when present) 2.

Body compressed, becoming very compressed towards tip of tail. Occipital region elevated, fleshy, swollen on sides behind eyes. Snout convex, flattened on sides. Cleft of mouth extends behind eye. Teeth

in jaws compressed, uniserial, subtriangular, acute, directed slightly backward, and getting gradually smaller towards angle. Vomerine teeth subulate, depressible, posterior one longer than anterior. None of teeth serrated. Tongue immovable. Posterior nostril situated above the anterior quarter of eye, rather small, rounded. Branchiostegal sac moderately developed. Origin of dorsal fin some little distance in advance of gill-opening; it is thickened at base, becoming gradually thinner towards margin. It is high throughout entire length, highest in centre, where it is rather more than half height of body. There is a decided notch in dorsal a little distance from tip of tail. Anal fin much lower than dorsal, of uniform height throughout. Tip of tail surrounded by fins.

Colour.—Golden brown covered with broad highly defined dark-brown reticulations, beneath which is a conspicuous network of very small reticulations of same colour as the larger ones. The reticulations extend to margin of dorsal fin. Dorsal fin narrowly margined with white between reticulations. Anal fin uniform black all along base, margin being pure-white. Inside of mouth cream-coloured, with reticulations same as the smaller ones found on body.

Variation.—I have received two specimens only of this most striking eel. This description is of the type specimen, which is about half-grown: its greatest length is 624 mm.; head, 74 mm.; greatest height of body, 45 mm.; eye, 7 mm. The paratype, which is an adult, is 1,040 mm. long; height of body, 70 mm.; eye, 12 mm. Beyond some difference in the measurements, doubtless due to age only, the two specimens are identical.

Affinities.—I sent one of these specimens to Mr. A. R. McCulloch for his opinion, and in writing me later he makes the following statement: "When I first saw this eel I felt certain that it was identical with a species from Lord Howe Island which I have previously identified as *Gymnothorax berndti* Snyder (*Bull. U.S. Fish Comms.*, vol. 22, pl. 4, and vol. 23, pl. 15), the striking colour-marking of the two being very similar. But a glance at its teeth showed that yours has compressed and roughly subtriangular teeth, whereas those of the Lord Howe Island specimen are long and subulate; further, the latter has a long row of vomerine teeth, and its eye is much smaller than in yours, with a much broader space separating it from the mouth. In my opinion you are pretty safe in regarding it as a new species."

Localities.—Whangaroa and Bay of Islands, North Auckland districts. Holotype and paratype in Auckland Museum.

Family SERRANIDAE.

Genus Epinephelus Bloch.

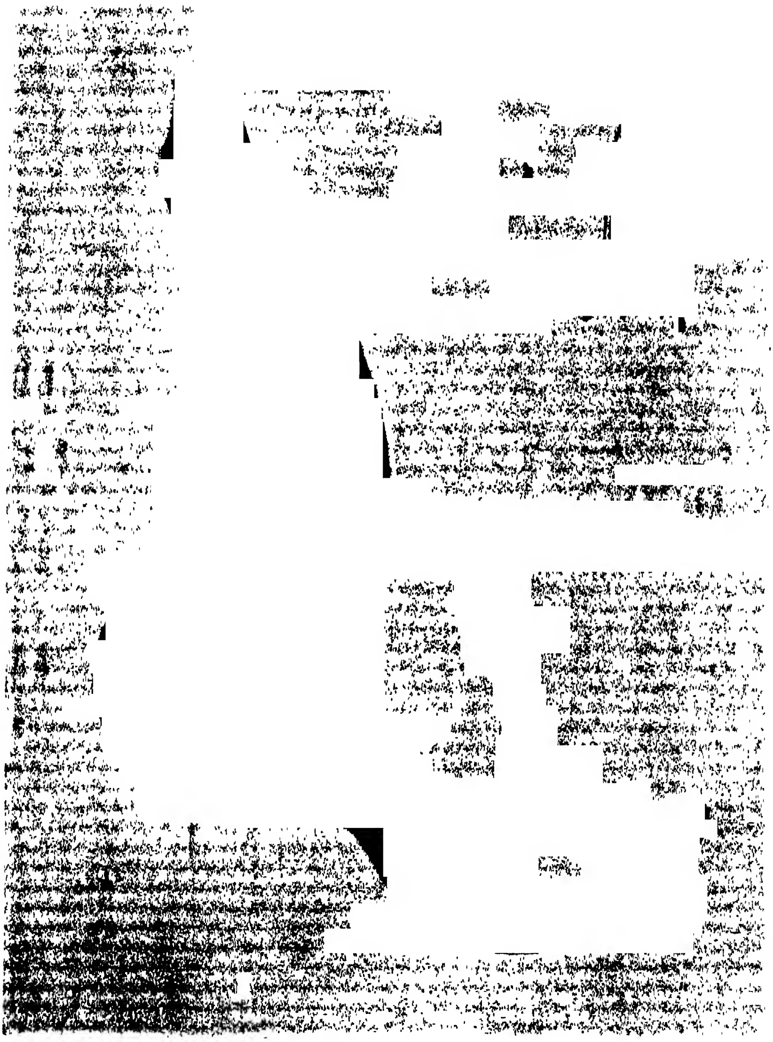
Epinephelus octofasciatus n. sp. (Plate 95.)

Br. 7; D. xi/XIV; A. iii/IX; P. xvii; V. i/V; C. xiv/$\frac{1}{1}$.

About 130 scales between upper posterior margin of operculum and hypural joint; 31 between origin of dorsal fin and lateral line; and 57 more to ventral surface.

Depth before ventrals $2\frac{1}{2}$ in length to hypural joint; head $2\frac{3}{4}$ in same. Eye $5\frac{1}{2}$ in head, and 2 in snout. Maxillary $\frac{3}{4}$ diameter of eye; interorbital space $4\frac{3}{4}$ in head. Caudal peduncle $7\frac{3}{4}$ in length to hypural joint.

Body compressed, covered with small ciliated scales, very much smaller on nape and along base of first dorsal fin. They get suddenly larger below second dorsal, about subequal with those in centre of body, then becoming



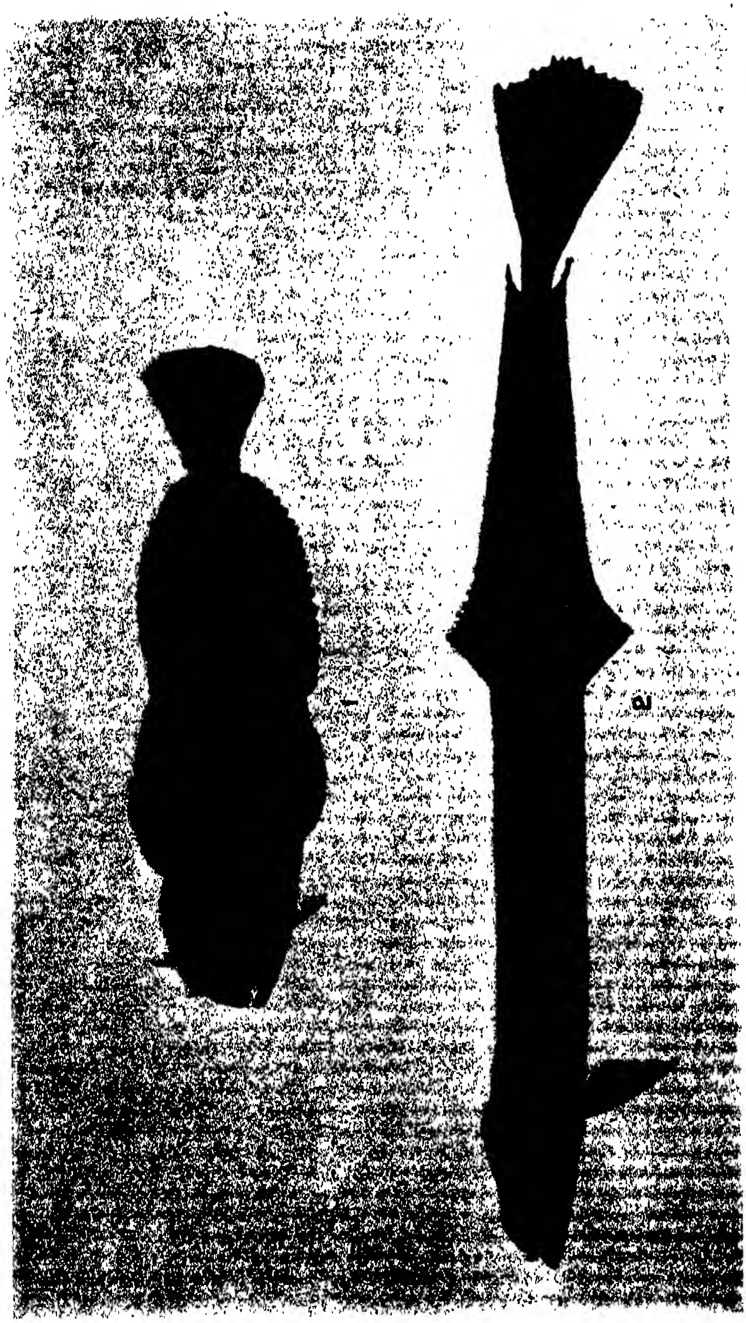
L. T. Griffin, del.

Gym *pri* Ogilby.

Gym n. sp. *L. T. Griffi*

Griffin, del.

Epi n. sp.



[L. T. Griffin, del.

FIG. 1.—*Blennius laticlavius* n. sp. FIG. 2.—*Echeneis lineata* Menzies.

Tripterygion bucknilli n. sp.

A. R. McCulloch, *del.*

L. T. Gri del.

Cristiceps aura us Castelnau.

very small again on base of pectoral and over abdomen as far as vent. Very small "cycloid" scales cover membrane and rays of fins, but all spines are free from scales except at base. Lateral line with origin at upper posterior margin of operculum well defined. It runs obliquely backward as far as fifth-sixth dorsal spines, then, bending steeply downward to middle of caudal peduncle, passes into caudal.

Interorbital space, cheeks, and operculum covered with small cycloid scales, those on posterior and lower margin of preoperculum, suboperculum, and lower jaw being more or less embedded in skin. Nostrils placed close together, posterior one very large. Maxillary with supplemental bone, naked, exposed, and extending backward as far as anterior $\frac{1}{4}$ of eye. Premaxillary naked. Lower jaw projects slightly beyond upper, and furnished with strong lips. Throat naked. An outer set of small fixed canine teeth in both jaws, while all the inner ones are hinged at base and depressible, arranged in a band which is broadest in front, getting much narrower towards angle. A few slightly longer curved canines are found scattered about among smaller ones in both jaws. Strong fixed teeth present on vomer and palatine bones, tongue smooth. Operculum with upper posterior margin developed into a strong scaly flap, lower portion of which is produced forming a flexible spine. Three strong fixed spines on operculum, placed one above the other: top one small, exposed; centre one large, well exposed, and about in line with upper margin of flexible spine on the opercular flap; lowest spine the smallest, situated near base of central spine, and almost entirely hidden among the scales of operculum. Preoperculum with a strongly serrated posterior margin and angle, the serrae being directed obliquely upward on upper half, straight in centre, and downward at angle where they are a very little stronger. Gills 4; gill-rakers long, 15 on lower half of anterior limb; gill-membrane separate, pseudobranchiae present. Dorsal fin with origin in the vertical from the posterior margin of operculum composed of strong spines and rays. Its first spine very short, the fourth–sixth longest, equal to three times length of first, and about 3 in head; those following decrease in length gradually backward as far as last spine, which is a little longer than preceding one. Second dorsal somewhat elevated, rays directed backward, seventh the longest, a little longer than longest spine. Pectorals rounded, subsymmetrical, reaching backward to vertical from ninth–tenth dorsal spines. Ventrals with very strong spine somewhat longer than fourth dorsal spine. Anal with 3 very strong spines, the first short; nearly 2 in the third, which is subequal with ninth dorsal spine. Anal rays similar to second dorsal. The spines in all the fins covered with strong scaleless membrane, except tips, which are exposed. Caudal truncate.

Colour.—Body ground-colour dingy purple-brown, with 8 broad dark-purple bars reaching vertically downward, the first ending at top of operculum, those following descending to below middle of height. Belly dirty-white with a bluish tinge, margins of scales light purple-brown. Top of head and maxillary dark purple brown; upper half of the premaxillary dark purple-brown, the distal half becoming much lighter; lips dark purple-brown; throat light greyish-purple; Operculum dark greyish-purple; cheeks light greyish-purple; branchiostegal membrane dark greyish-purple. Eye, outer margin dark purple-brown, then a broad gold ring with the lens blue-black. Scaly membrane of first dorsal same colour as body, its upper margin, which is free from scales, being very dark brown. Second dorsal same as ground-colour of body, and broadly margined with very dark brown, almost black. Anal fin same as second

dorsal; pectorals same as second dorsal, but with a broad blackish band running through them almost mesially. Ventrals very dark, almost black, but somewhat lighter at base. Caudal same as second dorsal, and broadly margined with blackish-brown.

Described and figured from the holotype, which is 467 mm. long to hypural joint; head 165 mm. long; diameter of eye 28 mm.; greatest depth of body 187 mm.; width of caudal peduncle 61 mm.

Affinities.—The structural details are in many ways comparative with *E. septemfasciatus*, a rare fish figured in *Faun. Japonica, Pisces*, 1842, p. 11, pl. 4, fig. 1. It is described by Boulenger in the *Brit. Mus. Cat. Fish.*, vol. 1, ed. 2 (1895), p. 226. This species has several characters of more or less importance, and I give them here for comparative purposes. In *E. septemfasciatus* the eye is said to be subequal with length of snout, and maxillary to extend to posterior third, or as far as posterior border of eye. The serrae on angle of preoperculum much more pronounced with some directed forward on lower border, and bands on body are all very oblique.

Locality.—A single specimen in fine condition captured by hook and line at Arid Island, off the north-east coast of the Great Barrier Island, Auckland District, April, 1922.

Holotype in Auckland Museum.

Family BLENNIIDAE.

Genus Blennius Linné.

Blennius laticlavius n. sp. (Plate 96, fig. 1.)

Br. 6; D. xiii/XVIII; A. xx; P. xiv; V. iii; C. xi/$\frac{6}{7}$

Depth before ventrals $4\frac{1}{2}$ in length to hypural joint, and subequal with length of head. Eye $3\frac{3}{4}$ in head. Snout much longer than diameter of eye; interorbital space $\frac{1}{4}$ width of eye. Spinous dorsal as long as from tip of snout to base of pectoral rays, or nearly $3\frac{1}{2}$ in length to hypural joint. Second dorsal nearly 3 in total length including caudal; anal fin 3 in total including caudal; pectorals subequal with length of head; ventrals equal to width of eye; caudal peduncle 3 in head.

Body oblong, somewhat tapering, naked, showing muscular structure through skin. Lateral line with its origin at upper posterior angle of operculum slightly arched over pectoral, then, bending downward in even curve beneath last dorsal spine, it becomes almost lost, but may be traced as far as anterior portion of peduncle as a series of widely spaced pores; on peduncle it is quite lost.

Head naked, anterior profile of snout subvertical; orbital tentacle well developed, composed of five filaments attached at base, anterior of which is longest. A short bifid tentacle behind anterior nostril. Mouth horizontal; maxillary reaching backward to vertical from centre of eye. Minute canine teeth in single series in both jaws; none on vomer, palatine bones, or tongue. Upper posterior angle of operculum produced into membranous flap. A line of minute pores surrounds eye, and a few are also found on posterior margin of preoperculum and on anterior margin of preorbital. Gills 4; gill-rakers 8, on lower half of anterior limb, pseudobranchiae present.

Dorsal fin continuous, spinous portion lower than rays. The fifth to ninth spines subequal, and $1\frac{1}{4}$ times width of eye, second spine subequal with width of eye. In second dorsal rays increase in height gradually, sixth and seventh being longest, while those following gradually decrease

in length backward, the last being about ½ diameter of eye. The origin of anal is in vertical from first and second rays of dorsal. It is somewhat low, composed of simple thickened rays, centre ones longest, about ⅔ diameter of eye. Pectorals rounded, entirely composed of thickened simple rays which reach backward as far as vertical from last dorsal spine. Ventrals jugular, composed of 3 simple rays, centre one longest, all united by membrane for more than half their length. Caudal straight on dorsal and ventral margins, rounded on posterior margin, middle rays longest.

Colour.—The general colour in alcohol is—Body and lower part of head transparent yellowish-silver covered with minute purple dots. Top of head dark purple. A broad dark-purple lateral stripe passes from the eye to hypural joint. Dorsal spines and rays transparent white covered with minute purple dots, and a dark-purple streak on fourth-seventh spines. Anal with dark-purple band near tips of rays, and a row of purple dots placed alternately on membrane near body. Pectoral with dark-purple mark on two or three of its lower rays, the rest transparent white. Caudal transparent white. Muscular structure of body well marked. A row of minute open pores below lateral stripe on body, another row of minute pores on posterior margin of cheek. Eye silver and blue-black.

Described and figured from the holotype, which is 30 mm. long, to hypural joint. Head, 7 mm.; height of body, 6 mm.; eye, 1½ mm.; caudal peduncle, 1½ mm.

I have received a good number of specimens, obtained at various seasons of the year; these range in length from 12 mm. to the length of the one here described; which is the largest that has yet been found.

Locality.—Mount Maunganui, Bay of Plenty. Found in deep crevices between large boulders where the surf has free ingress and egress.

Holotype and paratype in Auckland Museum.

Genus CRISTICEPS Cuv. et Val.

KEY TO THE NEW ZEALAND SPECIES.

A. Anterior spine placed just before front margin of eye. Two dorsals separate .. .. *aurantiacus.*

AA. Anterior spine over hinder portion of eye. First dorsal either distinct from or joined to base of second .. .. .. *australis.*

Cristiceps aurantiacus Castelnau. Crested Weed-fish. (Plate 98.)

> *Cristiceps aurantiacus* Castlenau, *Proc. Linn. Soc. N.S. Wales*, vol. 3, p. 386, 1879; McCulloch, *Rec. Austr. Mus.* vol. 7, No. 1, p. 38, pl. 10, 1, 1908; Stead, *Fish. Austr.*, 1906, frontispiece.

Br. 5; D. iii/XXIX/V+ii; A. ii/XXIV; V. iii; P. ix; C. x.

Depth of body below middle of pectoral 5 in length to hypural joint, or equal to length of head. Eye 5½ in head, interorbital space 7⅔ in same. Width of caudal peduncle rather more than ½ diameter of eye. Pectoral subequal with length of head.

Body elongate, much compressed, and sparsely covered with rudimentary scales, dorsal and ventral margins subequal. Snout subconical, length about 1½ times width of eye. Maxillary extends backward slightly beyond posterior border of eye. A branched tentacle on snout, and another long simple one attached to upper margin of eye. Jaws equal in front, and furnished with band of villiform teeth much more numerous and crowded

anteriorly in upper jaw than in lower. Fine teeth are also present on vomer and palatine bones; none on tongue. Operculum oblique, pointed on its upper posterior margin. Gills 4, gill-rakers 8 on lower half of anterior limb. Lateral line curved over operculum, then, sloping steeply behind pectoral, passes to caudal. Origin of first dorsal fin just before eye. Anterior spine longest, equalling distance from tip of snout to posterior margin of operculum. Second spine subequal to first, whole third is as long as anterior rays of second dorsal, to which it is not connected by membrane, and separated from it by space equal to width of operculum. Second dorsal commences slightly in advance of middle of operculum. Its first 29 rays are simple, and are followed by 7 simple articulated rays, the last 2 of which are short and separated from the others by interspace, and then connected to middle of caudal peduncle by fine membrane. Anal fin has origin in vertical from eleventh second dorsal ray. Similar in character to second dorsal, but its rays much shorter. Ventrals jugular, simple, centre ray being longest. Pectoral reaches backward as far as twelfth second dorsal ray. Caudal similar to pectoral. Caudal peduncle long, slender.

Colour. The colour of all species of this genus varies to an extraordinary degree. The specimen now under examination was a beautiful rose-pink when fresh, with a light-violet tint overlying the whole fish, the marbling on the body deep rose, a few scattered lemon-yellow spots of various sizes spread over abdomen and margins of operculum. First dorsal pale rose along base, getting deeper on margin, the light patches being transparent straw-white. Anal similar to dorsal in colour but somewhat lighter. Pectoral and caudal same as body-colour. Ventral pale rose barred darker. Tentacle on snout bright rose-pink; tentacle above eye black; eye rose-pink and pale blue-black, with a black streak descending from lower border to bottom of preoperculum, and ending in a single black dot on base of branchiostegals.

Described and figured from a specimen 139 mm. long to hypural joint. Head 29 mm. long, and greatest depth of body 27 mm.

Locality. Great Barrier Island and the Hauraki Gulf. Specimens have also been received from Tauranga, in the Bay of Plenty.

Genus Tripterygion Risso.

Tripterygion bucknilli n. sp. (Plate 97.)

Br. 6; D. iv/xvii/XII; A. xxv; V. ii; P. xvi–xviii; C. × $\frac{8}{8}$ × xvi.

About 40 scales between upper margin of operculum and hypural joint, and about 18 in transverse series.

Greatest depth of body nearly $4\frac{1}{2}$ in total length to hypural joint; head $3\frac{3}{4}$ in same. Eye $2\frac{1}{4}$ in head. Snout $\frac{3}{4}$ width of eye; interorbital space 3 in same. First dorsal fin as long as from tip of snout to centre of eye; second dorsal 3 times as long as first; third dorsal equals distance from tip of snout to posterior margin of preoperculum. Pectoral fin equal to length of head. Ventrals equal to height of head at centre of operculum. Caudal peduncle 3 in head.

Body oblong, compressed, upper and lower profiles subequal, and excepting abdomen (which is scaleless) the rest of body is covered in coarsely ciliated scales of fairly uniform size. Lateral line with its origin at upper angle of operculum slightly arched over base of pectoral, thence straight,

and ending below second spine of third dorsal. Second portion of lateral line with its origin vertically beneath last spine of second dorsal, it passes to caudal.

Head wholly naked; interorbital space very narrow, concave. Nostrils 2, placed parallel to each other, the inner one provided with a short bifid tentacle.

Mouth nearly horizontal; jaws subequal, pointed, and furnished with minute canine teeth crowded anteriorly. Minute teeth also present on vomer, none on tongue.

Maxillary extends backward almost to centre of eye. Gills 4; gill-rakers 7 on lower half of anterior limb. First dorsal with origin above centre of operculum, its two middle spines subequal, while the last is somewhat shorter than first, and united by rather high membrane to first spine of second dorsal. Spines of second dorsal are highest anteriorly, second to eighth being subequal, those following decrease in length gradually backward, the last having a very low membrane united to base of first ray of third dorsal. Third dorsal entirely composed of simple rays, first being equal to distance from tip of snout to centre of eye and subequal with fourth–sixth; remainder decrease in length gradually backward. Anal with origin in vertical from seventh second dorsal spine and ending below last ray of third dorsal. It is wholly composed of simple rays, the first being somewhat less than ½ diameter of eye, thence gradually increasing in length backward, the mesial ones being equal to width of eye, but the last three get rapidly shorter. Pectoral large, pointed, reaching backward to vertical from thirteenth spine of second dorsal. Ventrals jugular, composed of two simple rays united at base. Caudal rounded and composed of branched rays, procurrent ones being simple.

Colour.—Body silver with 9–10 broad vertical black bands which extend a little distance on to dorsal fins. Head, cheeks, and opercles silvery, shaded on interorbital and nape orange; eye bright cobalt-blue; dorsal fin broadly margined with brilliant orange, then a pale transparent orange stripe runs obliquely through it, while base is somewhat deeper in colour. The whole fin is crowded with minute dark-red dots. Anal dark brownish-red; pectoral pale transparent amber; caudal brownish red margined with brilliant orange the same as the dorsal.

Variation.—Described from the holotype, which is 26 mm. long to the hypural joint. I have examined nine specimens in all, and find little variations. In some specimens I counted as many as 10 vertical bands, including the narrow one on base of caudal, but beyond this they are identical in every respect.

Affinities.—At a first glance this fish appears much like *T. segmentatum* described by McCulloch and Phillipps in *Rec. Aust. Mus.*, vol. 14, No. 1 (1923), p. 20, pl. 4, fig. 3, but on examination there prove to be so many differences between them that I must regard this one as a new species, and on sending a specimen to Mr. McCulloch he fully concurs with this opinion, and I have to thank him for the fine plate accompanying this description.

Locality.—Several specimens from Mount Maunganui, Bay of Plenty, where it has been taken at various seasons by Dr. C. E. R. Bucknill, after whom I have named it. It appears to be very local, and is found in the deep crevices between the outer boulders where the surf has free ingress and egress.

Holotype and paratype in Auckland Museum.

Family ECHENEIDIDAE.

KEY TO NEW ZEALAND GENERA.

A. Inner ventral rays united by membrane free from abdomen.. .. *Echeneis.*
AA. Inner ventral rays attached to abdomen by membrane .. .. *Remora.*

Genus ECHENEIS Linnaeus.

Echeneis lineata Menzies. (Plate 96, fig. 2.)

Echeneis lineata Menzies, *Trans. Linn. Soc.*, vol. 1, p. 187, tab. 17, fig. 1, 1791; Guenther, Hist. of *Echeneis*, *Ann. Mag. Nat. Hist.*, ser. 3, vol. 5, No. 29, p. 398, May, 1860.

Br. 9; D. i/XXXV; A. i/XXXIII; P. xviii; V. i/V; C. xii/$\frac{8}{8}$.

Depth of body 14 in length to hypural joint, head 7 in same. Disc rather longer than head, 7½ in length to hypural joint. Eye 5½ in head or 2 in snout. Interorbital space 3⅓ times width of eye. Width of caudal peduncle 4⅓ in head.

Body elongate, covered with small scales partly embedded in the skin. Dorsal surface flattened for some little distance behind head. Sides also flattened below origins of vertical fins for a very short distance, but anterior and posterior to this they are much rounded.

Head depressed, tapering at jaws, and bearing an adhesive disc which contains 11 laminae, each margined with sharp closely-set cardiform tooth-like processes. The disc extends from posterior margin of maxillary to some little distance on to neck. Lower jaw extends beyond upper; it is flat and broad. Villiform teeth in both jaws, rather more numerous and crowded in lower than in upper. Teeth also present on vomer, palatine bones, and tongue. Eye of medium size, with a prominence in front. Maxillary extends backward as far as posterior nostril. Gills 4; gill-rakers 9, on lower half of anterior limb. Origin of dorsal fin vertically above that of anal, its length subequal with distance from origin to posterior margin of adhesive disc, and its last ray is produced. Anal similar to dorsal, but a trifle lower. Ventral situated below middle of pectoral. Pectoral high, almost in line with top of head. Middle caudal rays long, convex.

Colour.—Top of head and body as far as below middle of height dark blackish-blue, with a silvery lateral streak passing behind eye and pectoral and along side to caudal. Lower half of head light cream, almost white. Lower sides and belly cream-white. Dorsal fin nearly all black, tips of first to ninth rays being dull white. First to ninth rays of anal are yellowish-white, the remainder being smoky, getting gradually darker backwards but not so dark as dorsal. Pectoral dark-bluish, with a light bluish-green patch in the centre. Ventrals yellowish-white. Caudal with its outer rays yellowish-white at base, pure-white distally, all the middle rays being black.

Described and figured from a specimen 467 mm. long to hypural joint. Head, 65 mm.; eye, 12 mm.; greatest depth of body, 35 mm.; length of middle caudal rays, 64 mm.; length of adhesive disc, 70 mm.; anterior width of same, 20 mm.; posterior width, 30 mm.

Locality and Distribution.—One fine specimen received from the Bay of Islands, Auckland Provincial District, in April, 1923. This I believe to be the first record of the species being found in New Zealand waters. Guenther records it from the Atlantic and Pacific Oceans between the tropics.

Australasian Patelloididae.

By W. R. B. OLIVER.

[*Read before the Wellington Philosophical Society, 24th September, 1924; received by Editor, 31st December, 1924; issued separately, 26th April, 1926.*]

Plate 99.

THE classification of the Patelloididae presents such difficulties that few attempts have been made to ascertain the relationships of the many species that have been described under Eschscholtz's genus *Acmaea*, which includes the bulk of the family. The other genera included in the family, *Scurria* and *Lottia*, are American, and do not call for further notice here. A number of genera have been from time to time proposed for the species of this family, but not for the purpose of breaking up the *Acmaea* group, except, so far as I am aware, in two instances. Dall, in *Amer. Journ. Conch.*, vol. 6, 1871, founded the subgenera *Collisella* and *Collisellina* on characters of the radula; and Iredale, in *Trans. N.Z. Inst.*, vol. 47, 1915, proposed *Atalacmea*, *Radiacmea*, *Parvacmea*, and *Notoacmea* for New Zealand species, mainly on shell characters. It is not the purpose of this paper to discuss the classification of the family, but merely to put on record some observations on the New Zealand and Australian species. A few preliminary remarks of a general nature only, mainly on the characters of the shell and radula, will therefore be offered.

The shells of Patelloididae vary from large limpet-like shells to minute thin and hyaline shells. The shell of *Lottia* is in texture very similar to that of *Cellana*. The ribbing, inner surface, and colouring are comparable. *Patelloida alticostata*, on the other hand, has a shell with high ridges and a white porcellaneous interior recalling that of *Scutellastra*. The larger species of *Notoacmea*, which are also the most variable—namely, *pileopsis* and *septiformis*—have the young shells thin. They increase in thickness with age but retain the glassy interior. Finally, *Notoacmea daedala* and *Atalacmea fragilis* have extremely thin, hyaline, and translucent shells.

Each row of teeth in the radula of the Patelloididae is usually composed of an anterior element of two teeth close together in the middle line, a posterior element of four or more teeth not meeting in the middle line, and, in three genera, one or two marginals. The two anterior teeth I have interpreted as centrals, comparing them with those so named in the Patellidae. They are functional in all species. The four teeth of the posterior element are classified as laterals. Of these the inner ones only appear to be functional in all the genera except *Tectura* and *Radiacmea*, in which all the teeth appear to be functional. Marginals, present in *Patelloida, Chiazaemea, Asteracmea*, and *Collisella*, are small, and therefore probably not functional. I have adopted a simple formula as sufficiently showing the nature of the teeth. A median central tooth would be indicated by an odd number of centrals, but none occurs in the Patelloididae. It occurs in certain of the Patellidae, where, however, it is functionless. There is a considerable amount of difference between broad teeth with wide recurved cusps, as in *Patelloida*, and the long curved subulate teeth of *Notoacmea*. The characters of the radula have been used in defining the genera and subgenera.

Apparently the shell and radula characters do not always run parallel. By this I mean that species whose shells are alike have quite different teeth, while, conversely, the same radula formula is found in species having very unlike shells. Thus the shells of *Tectura testudinalis* from British seas agree very closely with those of *Notoacmea septiformis* from Tasmania, but the teeth, while agreeing in number, differ in arrangement and character. Conversely, while the shells of *Collisella spectrum* from California and *Patelloida alticostata* from Australia may be compared, *Collisella* possesses but one marginal tooth on each side while *Patelloida* has two. Again, Dall has grouped in the one genus *Collisella*, on account of agreement in a radula formula 1.2.2.2.1, *Collisella spectrum*, and *C. asmi*. But shells with more different texture and shape could scarcely be found in the family.

By treating the principal shell and radula characters as of equal value, eleven definable groups, besides *Scurria* and *Lottia*, may be made out. These, so far as they affect the Australasian species, will be treated as distinct genera in the account which follows. In America generally, and in north temperate seas, there is a group typified by *Collisella pelta* with thick, ribbed, porcellaneous shells, and the teeth of the radula 1.2.2.2.1. Dall's genus *Collisella* includes these, as well as others with the same radular formula but quite different shells, as *asmi*. A second northern group is that which includes *testudinalis*, and is characterized by thin, smooth, sometimes almost translucent shells, and with the teeth of the radula 0.2.2.2.0. To this group the name *Tectura* should be applied. A third group might be defined as including thin smooth shells with animals having the teeth of the radula 1.2.2.2.1. This would include such species as *asmi*, *paleacea*, *strigatella*, and suchlike.

In the Indo-Pacific region eight groups may be defined in a similar way. Three—*Patelloida*, *Chiazacmea*, and *Asteracmea*—have the radular formula 2.2.2.2.2; whilst five—*Radiacmea*, *Potomacmaea*, *Actinoleuca*, *Notoacmea*, and *Atalacmea*—have no marginals, the formula being 0.2.2.2.0. The genera are defined on the characters of the teeth and the shell.

It will appear from the foregoing synopsis that the geographical area occupied by the Patelloididae may be divided into two great regions. One is the western coast of America, with extensions round Cape Horn, through the Panama to the West Indies, across the Pacific to Japan, and, possibly, by the Arctic Sea to the North Atlantic. This region is characterized by the presence of *Collisella*, *Tectura*, *Scurria*, and *Lottia*. The other region is the Indo-Pacific, characterized by *Patelloida*, *Asteracmea*, *Notoacmea*, *Atalacmea*, *Actinoleuca*, and *Radiacmea*. The two faunas mingle only in the Malayan region—at least, as far as can be judged on the available information. The two areas where species are most extensively developed are the west coast of North America, and the south coast of Australia, with Tasmania and New Zealand.

In the genera having most teeth in the radula generally only the two centrals and the two inner laterals are functional. From this fact I infer that a large number of teeth is a more archaic character than a small number.

Scurria, which possesses a branchial cordon as well as a plume, and has also functionless marginal and outer laterals, is probably an archaic form. *Patelloida* and *Asteracmea*, with the highest number of teeth, are well developed along the south coast of Australia. This region, with Tasmania and New Zealand, is also the headquarters of four genera without marginal teeth. All these circumstances point to a great development of forms in the Southern Hemisphere. On the other hand, *Collisella*

perhaps dispersed from the North Pacific. The family as a whole is mainly circum-Pacific in distribution, and may have originated somewhere on the borders of that ocean, but as it is no doubt of very ancient date, Cambrian and Silurian fossils having been referred to it, it is scarcely profitable to speculate further.

If I am right in supposing that the evolution of species in this family has been in the direction of the reduction of teeth in the radula and the development of thin shells as in *Tectura* and *Notoacmea*, also the loss of a branchial cordon as the plume took its place, then it might be inferred that the family Patelloididae is an offshoot of Patellidae. The shells of *Lottia* and *Patelloida*, archaic genera in the above sense, resemble those of *Cellana* and *Scutellastra* respectively.

The following key indicates the relationship of those genera of Patelloididae that have so far been described. *Scurria*, *Lottia*, *Colliselia*, *Tectura*, and *Potamacmaea* are extra-Australasian genera.

I. Branchial cordon and plume present.
- A. Branchial cordon complete .. .. *Scurria.*
- B. Branchial cordon interrupted in front .. .. .. *Lottia.*

II. Branchial plume only present (but see *Asteracmea*, p. 563).
- A. Radula with 2 marginal teeth on each side.
  1. Shell porcellaneous, strongly radiately ribbed .. *Patelloida.*
  2. Shell smooth, or with small low ribs .. .. *Chiazacmea.*
  3. Shell minute, translucent, smooth, or finely radiately striated or ribbed .. .. *Asteracmea.*
- B. Radula with 1 marginal tooth on each side .. .. *Collisella.*
- C. No marginal teeth; central and lateral teeth diverging in two rows from median line.
  - *a.* Teeth with short rounded cusps.
    1. Shell porcellaneous, radiately ribbed .. .. *Radiacmea.*
    2. Shell thin, hyaline, smooth .. .. .. *Tectura.*
  - *b.* Teeth broad and straight with saw edges .. .. *Potamacmaea.*
  - *c.* Teeth broad with straight edges in two diverging lines.. *Naccula.*
- D. No marginal teeth; central teeth in advance of lateral, which are in a transverse row.
  1. Shell conical, porcellaneous, finely ribbed .. *Actinoleuca.*
  2. Shell with apex usually anterior, with an inner hyaline and an outer shelly often dark-coloured layer .. .. *Notoacmea.*
  3. Shell much depressed, hyaline .. .. *Atalacmea.*

Genus PATELLOIDA Quoy and Gaimard.

The shells of this group are thick, porcellaneous in texture, with radiating ridges having a tendency to develop seven larger than the others. The colour inside is either entirely white or with colour at the margin and on the spatula which is often spotted with lighter. *P. latistrigata* is the darkest-coloured species, being some shade of brown both within and without.

The radula bears 2 anterior centrals with broad recurved cusps; 2 laterals posterior to these on each side, the inner with broad recurved cusps, the outer small; and 2 small marginals on each side. Only the centrals and 2 inner laterals appear to be functional.

The genus comprises about 6 species, distributed over Malaya, western Polynesia, Australia, Tasmania, and New Zealand. They are mostly found on seaweed-covered rocks about low-tide mark, where they are quite common, but they occur also higher up in the intertidal belt. *P. alticostata*, with a length of 57 mm., appears to be the largest species.

Patelloida may on conchological characters be divided into two subgeneric groups, *Patelloida* and *Collisellina*.

Subgenus Patelloida Q. & G.

Patelloida Quoy and Gaimard, *Voy. "Astrolabe," Zool.*, vol. 3, 1834, p. 349. Type: *P. rugosa* Q. & G.

Shell with regular prominent ribs. Colour predominantly white, the spatula and interior margin dark.

Patelloida (Patelloida) rugosa Q. & G.

Patelloida rugosa Q. & G., *Voy. "Astrolabe," Zool.*, vol. 3, p. 366, pl. 71, f. 36, 37, 1834. *Amboyna* (type in Mus. Hist. Nat., Paris). *Acmaea rugosa* (Q. & G.): Pilsbry, *Man. Conch.*, vol. 13, p. 52, pl. 37, f. 5, 6, 1891.

I have not seen this species, and can find no information concerning it beyond the original description. This is translated by Pilsbry, and Quoy and Gaimard's figures are reproduced. It is recorded from Amboyna only.

Gray designated this species as type of *Patelloida*. Iredale states that it is referable to the group including *saccharina*, while Pilsbry suggests a comparison with *P. corticata*. It is desirable that the dentition of this species be described.

Patelloida (Patelloida) nigrosulcata (Reeve).

Patella nigrosulcata Reeve, *Conch. Icon.*, vol. 8, pl. 30, f. 84, 1855 (type in British Museum). *Patella stellaeformis* Reeve var. *nigrosulcata* Reeve: Pilsbry, *Man. Conch.*, vol. 13, p. 100, pl. 61, f. 66, 67, 1891. *Acmaea patellavecta* Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 195, pl. 15, f. 5–7; pl. 16, f. 5, 1912 (Cape Naturaliste). *Patelloida patellavecta* (Verco): Hedley, *Journ. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916. *Patelloida nigrosulcata* (Reeve): Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 41, p. 708, 1917.

This species is characterized by about 40 low rounded ribs, margin slightly crenulated, interior white with grey and brown border, exterior white and eroded.

The dentition is distinctive. The centrals are broad and short, also the laterals, of which the outer are the broader. As is usual in the genus, the marginals are small.

According to Verco, from whose article the information here given is taken, this species is related to *P. alticostata*.

Bionomics.—Living on the shell of *Patella neglecta*, nearly every example of which above 25 mm. in length carries one or more.

Distribution.—Western Australia: Cape Naturaliste, King George Sound, Ellensbrook, Yallingup.

Patelloida (Patelloida) alticostata (Angas).

Description.—Shell characterized by its usually high conical shape and high equidistant and nearly even-sized ribs; the normal number for young shells seems to be 14, increasing with age to about 28. Shell: inside white with spatula dark brown or black at front and round posterior border; margin yellowish with black patches in interspaces between ribs; dark rays often faintly seen through inner layer of shell.

Radula has centrals approximating with broad blunt recurved cusps showing a slight groove most marked on inner face; inner laterals short, with very broad blunt recurved cusps, upper surface of curved portion concave, outer laterals minute; marginals, 2 on each side, transparent; centrals and lateral cusp brown colour with dark-brown tips. (Specimens from Corny Point, South Australia.)

Good accounts of this species are given by Verco (*Trans. Roy. Soc. S. Aust.*, vol. 30, p. 209, 1906) and Tenison-Woods (*Proc. Roy. Soc. Tas.*, *1876*, p. 50, 1877).

This species is fairly uniform throughout its range. Two subspecies are here accepted, based on characters of sculpture, colour, and size, all somewhat variable.

Bionomics.—Intertidal from about half-tide mark down.

Distribution.—Tasmania: and from Geraldton, Western Australia, round the south coast to South Queensland.

(*a.*) Subspecies **alticostata** (Angas).

Patella alticostata Angas, *Proc. Zool. Soc.*, 1865, p. 56 (Port Lincoln, S. Aust.). *Acmaea costata* (not Sowerby): Tenison-Woods, *Proc. Roy. Soc. Tas.*, *1876*, p. 50, 1877: Pilsbry, *Man. Conch.*, vol. 13, p. 51, 1891: Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 21, p. 382, 1908. *Acmaea alticostata* (Angas): Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 189, 1904: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 209, 1906; vol. 36, pp. 183, 197, pl. 16, f. 3, 4 (radula), 1912: Iredale, *Proc. Zool. Soc.*, 1914, p. 670. *Patelloida alticostata* (Angas): Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916.

Distinguished by the following characters: Shell depressed or elevated, large, up to 57 mm. long, ribs high and rounded. Interior white, spatula black in front and behind, margin narrowly black and yellow banded.

Distribution.—Tasmania; and the west and south coasts of Australia from Geraldton to Bass Strait.

(*b.*) Subspecies **antelia** Iredale.

Patella costata (not Sowerby*): Angas, *Proc. Zool. Soc.*, 1867, p. 221. *Patelloida alticostata* Angas, subspp. *antelia* and *complanata* Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 234, 1924 (Sydney).

This subspecies differs from the subspecies *alticostata* only in characters which are somewhat variable, so that the two subspecies intergrade; but the distinction is convenient, as the geographical range of each is different though conterminous. Iredale divides the present form into two, but I scarcely think such a course is justified. Possibly there may be variations due to differences of exposure. It may be defined as follows:—

Shell usually elevated, small, under 30 mm. long, ribs low, angled. Interior whitish, much stained with black, spatula black in front and behind, margin black-and-yellow banded or with a broad black band.

Bionomics.—At Long Reef, New South Wales, it occurs in the barnacle association in the mid-tide belt, and in the tunicate association in the low-tide belt.

Distribution.—Coasts of eastern Victoria, New South Wales, and South Queensland.

Patelloida (Patelloida) corticata.

Apparently a highly plastic species, the distinguishing characters of which are the thick shells, with the apex forward and usually low; ribs irregular, margin crenulate. Young shells sometimes show seven ribs more prominent than the rest. Inside coloration very various.

* The erroneous application of Sowerby's name *Lottia costata* to the present species has on several occasions been suggested, but only recently has it been disposed of satisfactorily. Tomlin (*Proc. Mal. Soc.*, vol. 16, p. 98, 1924) identifies it with *Patella longicosta* Lam.

The nearest relative of this species is *Patelloida alticostata* of Australia, from which it differs in its depressed form, irregular ribbing, and coloration.

Dentition 2.2.2.2.2; centrals and laterals broad with recurved cusps; outer laterals of moderate size and apparently functional; dentition essentially like that of *P. saccharina.*

Three forms, not very well defined, may perhaps be recognized. They will be described separately, and, for the sake of uniformity, called subspecies. They are, however, not of the same value as the subspecies *Patelloida flammea* and *P. latistrigata*: they might be described as environmental forms.

Distribution.—Sunday Island (Kermadec Group); throughout New Zealand from the North Cape to Stewart Island; Chatham Island.

(*a.*) Subspecies **corticata** (Hutton).

Acmaea corticata Hutton, *Man. N.Z. Moll.*, p. 89, 1880 (Dunedin: type in Canterbury Museum); *Trans. N.Z. Inst.*, vol. 15, p. 127, pl. 15, f. L (dentition), 1883; *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 372, 1884. *Acmaea lacunosa* (not Reeve): Pilsbry, *Man. Conch.*, vol. 13, pp. 52, 168, pl. 37, f. 9–11, 1891. *Acmaea stella* subsp. *corticata* Hutton: Suter, *Proc. Mal. Soc.*, vol. 7, p. 325, pl. 27, f. 38-41, 1907; *Man. N.Z. Moll.*, p. 74, pl. 5, f. 17, 1913: Bucknill, *Sea-shells N.Z.*, p. 14, pl. 5, f. 2, 1924.

In this form there are 25–30 fairly even-sized ribs; apex high and about the anterior third. Inside bluish-white with radiating bands of brown sometimes more or less obscured by the nacreous layer.

It varies somewhat, passing into the next subspecies, from which it may be distinguished by the higher form, more numerous ribs, and regular colour-bands; it is also smaller, 14 mm. being the usual length of the adult.

Bionomics.—Found on rocks between tide-marks, often in very exposed situations, such as rock-faces in the surf zone, where it is common. It is invariably covered with *Melobesia*, which also covers the rock-surface on which it lives. It is a member of the large-brown-algae associations and the *Modiolus pulex* association at St. Clair.

Distribution.—Te Henga, Banks Peninsula, Shag Point, Otago Peninsula, Stewart Island, Chatham Island (Suter).

(*b.*) Subspecies **corallina** n. subsp.

Acmaea stella (not Lesson): Suter, *Proc. Mal. Soc.*, vol. 7, p. 324, pl. 27, f. 36, 37, 1907; *Man. N.Z. Moll.*, p. 73, pl. 5, f. 16, 1913: Iredale, *Proc. Zool. Soc.*, 1914, p. 671: Bucknill, *Sea-shells N.Z.*, p. 14, pl. 5, f. 1, 1924. *Patelloida stella* (not Lesson): Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924. *Acmaea lacunosa* (not Reeve): Hutton, *Macleay Mem. Vol.*, p. 72, 1893.

Distinguished from *corticata* by its large size, depressed form, fewer ribs (usually under 25), and lighter coloration, some shells being entirely white within. It is the common form in New Zealand. Type in the Dominion Museum, Wellington.

In all its characters this subspecies is subject to great variation. At Breaker Bay, Cook Strait, there are found in the brown-algae formation large depressed forms with broad irregular outlines; this is the form called by Suter *stella*. The largest are found in the vicinity of Wellington City sewer-outlet, and their large size is probably due indirectly to increased organic matter in the water. Sometimes the shells are considerably elevated, approaching *corticata.*

The margin of the shell seems readily to adjust itself to the irregularities of the rock-surface on which the animal lives. It is thus seldom in one plane. Occasionally also, one side of the shell, on coming into contact with a projecting piece of rock, stops growth in that direction but continues in others, so that the shell becomes strongly inequilateral or truncated in front or behind. Such shells are found at Breaker Bay, Cook Strait.

It is difficult to describe the variety of colours exhibited by the shells of this subspecies. In few cases only is the outside colour visible, when it is seen to be greenish with brownish radiating lines in the interspaces between the ribs. The inside markings are always some shade of brown or purplish-brown on a white or bluish-white ground. Occasionally there are no markings, the interior being quite white; more frequently there are blotches and radiating lines, while sometimes the whole inside is coloured. There are indications of some relation between the amount of colouring present and the degree of exposure of the shell to the light, for the shells with the least colouring are those found on seaweed-covered rocks near low-tide mark, while those with the inside entirely coloured are small shells without a covering of algae, and living near high-tide mark. Patches of brown colour on the inside generally occur opposite eroded areas on the outside. A similar fact has been observed by Thomson in the genus *Cellana*. The inside of shells covered with pink *Melobesia* often has a pinkish tinge.

Reviewing an extensive series of specimens collected at many localities, it seems impossible to define recognizable forms. As may be inferred from the preceding observations, variation is apparently controlled by external factors, such as exposure, light, and food-supply. In this last connection it is to be noted that there is a rough correspondence between the size of the shell and the height of its station above low-tide mark. The following notes on shells from various localities indicate the more conspicuous forms the subspecies takes:—

Sunday Island: One specimen, in no way different from specimens from the north of New Zealand. It is depressed and wide, and covered with *Melobesia*, with the inside brownish over the whole surface.

Parenga: On rocks near high-tide mark. Little algae on outside; some shells quite free. Interior of all more or less brown, the spatula and margin being darker than the rest. Length of largest shell collected, 17 mm.

Raglan: Shells from the upper part of the intertidal belt have a dark-brown margin and spatula with bluish-white between. Specimens from the barnacle formation lower down are much lighter in colour.

Mount Maunganui: Barnacle formation, between tides. All shells rather dark colour inside, the ground-colour between the spatula and margin being bluish-white. Several of the smaller specimens show seven rays more prominent than the rest.

Stephen Island: In *Carpophyllum* association. Large wide shells thickly covered with *Melobesia*. Inside white or pinkish.

Breaker Bay, Cook Strait: The largest shells I have seen come from this locality. They are irregularly ribbed, very rarely seven rays larger than the others. Length, 22 mm.; breadth, 27 mm. In these large specimens the interior is usually white with dark-brownish patches in the central area and sometimes a pinkish margin. Although Suter (*Man. N.Z. Moll*, p. 73) referred these larger specimens to *stella*, his description does not cover them, but is merely an amended translation of Lesson's.

Bionomics.—The subspecies *corallina* is extremely common in the intertidal belt from high- to low-water mark. It is most abundant on seaweed-covered rocks in the low-tide belt.

With very few exceptions the shells are covered with a thick growth of the coralline alga *Melobesia*, on which there also occasionally grows tufts of *Corallina*. In fact, the shells appear to be free from algae only when growing in situations not suited to the growth of seaweed.

Distribution.—Sunday Island, Kermadec Group; Spirits Bay, Parenga, Bay of Islands, Little Barrier Island, Raglan, Mount Maunganui, Napier, Cook Strait (north side), Stephen Island, Lyttelton, Shag Point, Stewart Island (rare), East Cape, and Taumaki Island (Suter). Pliocene of the Wanganui district (Hutton).

(c.) Subspecies **pseudocorticata** (Iredale).

Acmaea pseudocorticata Iredale, *Trans. N.Z. Inst.*, vol. 40, p. 379, 1908 (Lyttelton Harbour). *Acmaea stella* var. *pseudocorticata* Iredale: Suter, *Man. N.Z. Moll.*, p. 74, 1913.

This form is characterized by its small size, elongate form, lower ribs, and consequently little-crenulated margin. Colour outside greenish with radial brown markings on the interstices between the ribs, especially near the margin. The inside may be brown, lighter just inside the muscle-scar, or it may be yellowish with black radiating bands outside the muscle-scar.

It differs from the subspecies *corticata* only in minor characters that one would expect to find in shells living along the upper edge of the intertidal belt. It should not be ranked higher than a subspecies of the species *corticata*.

Bionomics.—On rocks in the intertidal belt near high-water mark, especially in baths and harbours. It does not support the coralline algae *Melobesia*, probably because its station is higher than that of the algae.

Distribution.—Lyttelton, Taylor's Mistake, Shag Point, Portobello, Otago Peninsula.

Patelloida (Patelloida) hamiltonensis Chapman and Gabriel.

Patelloida hamiltonensis Chapman and Gabriel, *Proc. Roy. Soc. Vict.*, vol. 36, p. 24, pl. 1, fig. 3, 1923.

Judging by the description and figure, this species would fall into the subgenus *Patelloida*. It is characterized by about 10 rather prominent radiating ribs, with finer riblets in the interspaces.

Distribution.—Victoria: Muddy Creek (Lower Pliocene–Kalimnan).

Subgenus COLLISELLINA Dall.

Collisellina (section of *Collisella*) Dall, *Amer. Journ. Conch.*, vol 6, p. 259, 1871. Type: *Patella saccharina* Linné.

Shell with 7 ribs more prominent than the others, 3 anterior and 4 posterior. Colour predominantly dark, the spatula usually spotted.

Patelloida (Collisellina) saccharina (Linné).

Patelloida saccharina is a polymorphous form with high ribs having a tendency for 7 to be more prominent than the rest. The interior may be entirely white with a black-and-yellow margin, or the spatula may be cream or pale brown variously blotched and spotted, or even entirely dark brown.

Dentition 2.2.2.2.2, the centrals and inner laterals with broad recurved cusps, the remaining teeth small and probably functionless.

Although *Patelloida saccharina* occurs under different forms, they appear properly classified as a single species. From the specimens before me I conclude that there are two principal forms—a southern one having a spotted spatula, and a northern one in which the spatula is either white or blotched with brown but that these two forms merge in the Western Pacific.

Distribution.—From the Andaman Islands to Japan and southward through the Malay Archipelago to tropical Australia from the Monte Bello Islands on the west to Port Curtis on the east. It extends into western Polynesia as far as the Fiji Islands and Samoa, also Funafuti (Ellice Group).

(*a.*) Subspecies **saccharina** (Linné).

Patella saccharina Linné,* *Syst. Nat.*, ed. 10, p. 781, 1758: Reeve, *Conch. Icon.*, pl. 28, f. 72, 1855: Lisshke, *Jap. Meeres-Conchyl.*, p. 113, 1869: Dunker, *Index Moll. Man. Jap.*, p. 155. *Patella stellaris* Bolten, *Mus. Bolt.*, p. 12, 1798. *Patella lanx* Reeve, *Conch. Icon.*, vol. 8, pl. 30, f. 82, 1855 (Japan). *Acmaea saccharina* (Linné): Pilsbry, *Man. Conch.*, vol. 13, p. 49, pl. 36, f. 60–62, 78; pl. 18, f. 31, 32; pl. 24, f. 12, 13 (*P. lanx*); pl. 42, f. 83 (radula), 1891: Hanley, in Wood's *Index Test.*, ed. 2, p. 185, 1856: Hedley, *Mem. Austr. Mus.*, vol. 3, p. 402, 1899. *Collisella saccharina* (Linné): Dall, *Am. Jour. Conch.*, vol. 6, p. 259, pl. 15, f. 18 (radula), 1871.

Specimens from the Philippines which I have seen have 7 large ribs with smaller ones in between, the interior is white, the margin yellow, and black patches between the ribs. This form is typical *saccharina*. In the Japanese specimens described by Reeve as *Patella lanx* there are numerous nearly equal-sized ribs, but shells from Japan which I have examined have 7 dominant ribs and the interior is spotted or blotched.

Distribution.—Andamans, Philippines, Japan, Funafuti (Hedley).

(*b.*) Subspecies **stella** (Lesson).

Patella stella Lesson, *Voy. "Coquille," Zool.*, vol. 2, p. 421, 1830. *Patelloida stellaris* Q. & G., *Voy. "Astrolabe," Zool.*, vol. 3, p. 356, pl. 71, f. 1–4, 1834 (New Ireland). *Acmaea saccharina* var. *stellaris* (Q. & G.): Pilsbry, *Man. Conch.*, vol. 13, p. 50, pl. 36, f. 63, 64, 67, 68, 1891. *Acmaea saccharina* (Linné): Iredale, *Proc. Zool. Soc.*, 1914, p. 670. *Patelloida saccharina* (Linné): Hedley, *Journ. Roy. Soc. W. Aust.*, vol. 1, p. 36, 1916; *Trans. Roy. Geog. Soc. Austr.*, p. 13, 1918.

Lesson states that his *Patella stella* came from New Zealand, and Suter refers the common New Zealand species, *P. corticata*, to Lesson's name. Pilsbry, however, refers Lesson's species to *P. saccharina*, and this I believe to be the correct course. I have seen no New Zealand shells which could be covered by Lesson's description, which, however, agrees in every particular save the colour of the inside margin with Quoy and Gaimard's *Patelloida stellaris*. Lesson gives a description of the outside of his shell tallying with the tropical form. The New Zealand species is almost invariably covered with *Melobesia*, and no colour-pattern is visible. The spatula occasionally bears brown blotches; it is never spotted as Lesson describes. I have no hesitation, therefore, in restoring Lesson's name to the southern form of *Patelloida saccharina*.

Specimens living in the *Ostrea cucullata* association on rocks between tides, at Facing Island, Port Curtis, Queensland, have the apex eroded, and

* Linné gave the Barbadoes as the locality for his species, but this was an error. According to Robson, the type locality is the Philippines.

the ribs numerous and nearly of equal size, though usually 7 are larger than the others. The interior shows a pale-brown spatula dotted with dark brown; outside this it is white or bluish-white with a black-and-yellow banded margin. This appears to me to be the form described by Lesson as *Patella stella*, and by Quoy and Gaimard as *Patelloida stellaris*. In some of the Facing Island specimens a portion or even the whole of the spatula may be dark brown, obliterating the spots.

At Levuka, Ovalau, specimens were collected on rocks between tide-marks: they were deeply eroded. Some of the specimens possessed 7 main ribs with quite small ones between, as in the Philippine specimens; in others there were more numerous and more equal-sized ribs. In one specimen the interior was white with a black-and-yellow margin. In most of the others the space between the marginal band and the spatula was bluish-white, while the spatula was pale brown with dark-brown blotches and spots. These specimens seem to bridge over the difference between typical *saccharina* from the Philippines and typical *stella* from Port Curtis.

Iredale notes that the Australian form extends along the northern coast of Australia from Monte Bello Islands to Port Curtis. According to me, this form extends farther eastward into the Pacific as well.

Bionomics.—At Port Curtis the subspecies *stella* occurs abundantly on rocks between tide-marks, in the *Ostrea cucullata* association, and among algae in rock-pools. At Ovalau, Fiji Islands, it is common on intertidal rocks.

Distribution. — Monte Bello Islands, Camden Sound and Buccaneer Archipelago, Port Essington, Cape York, Port Curtis, New Ireland, Fiji.

Patelloida (Collisellina) latistrigata (Angas). (Text-fig. A.)

As a species *Patelloida latistrigata* is easily distinguished by the presence of ribs, which in the southern form show 7 more prominent than the rest, while the interior is especially characteristic, the spatula being pale brown, spotted or grained with dark brown and with a white border.

Radula of specimen from Frederic Henry Bay, Tasmania: Centrals with long narrow bases and long pointed projecting dark-brown cusps. Inner laterals with short bases and pointed projecting dark-brown cusps shorter than the centrals. Outer laterals very small. Marginals transparent, with short broad cusps.

Two well-defined subspecies may be recognized.

Distribution.—Tasmania and the south coast of Australia from South Australia to New South Wales.

(*a.*) Subspecies **latistrigata** (Angas). (Text-fig. A.)

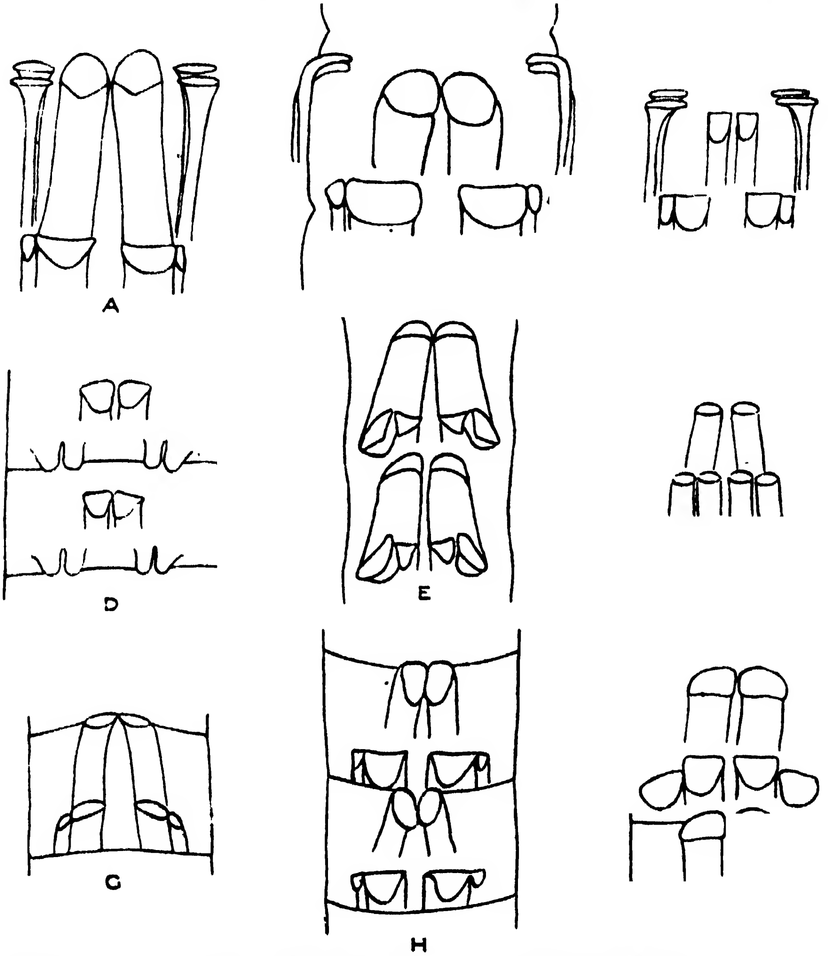
Patella latistriguta Angas,* *Proc. Zool. Soc.*, 1865, p. 154 (Aldinga Bay, S. Aust.). *Acmaea latistrigata* (Angas): Gatcliff and Gabriel, *Proc. Roy. Soc. Vic.*, vol. 21, p. 382, 1908. *Helcioniscus latistrigata* (Angas): Pilsbry, *Man. Conch.*, vol. 13, p. 143, 1891. *Acmaea marmorata* Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1875, p. 156, 1876 (South Tasmania); *l.c.*, 1876, p. 53, 1877: Pilsbry, *Man. Conch.*, vol. 13, p. 52, pl. 42, f. 66–68, 1891: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 210, 1906; vol. 36, p. 184, 1912: Tate and May, *Proc. Linn. Soc. N.S.W.*, vol. 26, p. 412, 1901. *Acmaea gealei* (not Angas): Pritchard and Gatcliff, *Proc. Roy. Soc. Vic.*, vol. 15, p. 197, 1903.

In the ordinary form of the species as it occurs in Tasmania, South Australia, and Victoria the spatula is closely marked with fine radiating

* Vercoe states that this is a half-grown example with broad radial stripes.

and anastomozing lines, dark brown on a lighter ground. Near the edge of the spatula these lines break up into dots, and the ground-colour becomes pure-white. In many cases 7 ribs are larger than the others, 3 in front of and 4 behind the apex.

The largest specimens I have seen some from South Australia, and measure 24 mm. in length. These were thick shells with high ribs and



Radulae of—A, *Patelloida latistrigata* (Angas); B, *Chiazacmea flammea* (Q. & G.); C, *C. heteromorpha* Oliver; D, *Actinoleuca campbelli* (Filhol); E, *Notoacmea petterdi* (Ten.-Woods); F, *N. helmsi* (Smith); G, *N. corrosa* Oliver; H, *N. badia* Oliver; I, *N. scopulina* Oliver.

deeply-eroded apexes. Specimens from Port Phillip show variation in the marking on the spatula. In one there are very fine lines, in another there are large dots.

Bionomics.—In Tasmania, in the Derwent Estuary, *Patelloida latistrigata* occurs on intertidal rocks near high-water mark, and in the *Mytilus planulatus* association in the mid-tide belt. These specimens are generally small (under 15 mm. in length), and have the apex eroded.

Distribution.—South Australia: Streaky Bay and St. Francis Island, eastward to Port Macdonnell (Verco), Aldinga Bay. Victoria: Coast generally, Cape Otway, Cape Schanck, Cape Patterson. Tasmania: Common on the coast generally, Derwent Estuary, Southport.

(*b.*) Subspecies **submarmorata** (Pilsbry).

Acmaea marmorata var. *submarmorata* Pilsbry, *Man. Conch.*, vol. 15, p. 52, pl. 42, f. 49, 70, 1891 (Port Jackson). *Patelloida submarmorata* (Pilsbry): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 236, 1924.

In New South Wales this distinct form of the species occurs. It is characterized by the numerous small ribs of nearly even size, the subcentral apex, the large dark spots on the spatula, and its narrow white border. As these spatula characters appear occasionally in Tasmanian and Victorian specimens, and the ribbing is variable in both forms, I consider *submarmorata* best classed as a subspecies of *latistrigata*. The largest specimens that I have seen measure 13 mm. in length.

Bionomics.—In New South Wales, on the coast near Sydney, I found the subspecies *submarmorata* common near high-tide mark and in the barnacle association in the mid-tide belt.

Distribution.—New South Wales: common in the vicinity of Sydney. Queensland (Verco). Victoria: Mallacoota (Iredale).

Genus Chiazacmea n. gen.

Shell smooth, or with low rounded ribs. Colour light with brown rays, a cross-pattern usually evident, spatula dark. Type: *Patelloida flammea* Q. & G. (Hobart) (as herein defined).

Chiazacmea flammea Q. & G. (Text-fig. B.)

Chiazacmea flammea is a polymorphic species, in which several rather distinct forms may be defined. This circumstance has led to numerous names having been bestowed on it. Characters diagnostic of the species are the elevated form with the apex about the anterior third, the radiating bands of colour usually with a cross-pattern most conspicuous, and the dark spatula.

The radula is here described and figured from a specimen of the subspecies *mixta* from Corny Point, South Australia. Centrals approximated, broad, ending in wide blunt recurved cusps. Inner laterals wider than the centrals, short, with broad recurved cusps, with the angles truncated and the upper curved margin concave. Outer laterals narrow, sharp-pointed. Centrals and laterals horn-colour with dark-brown cusps. Marginals 2 on each side, small, narrow, transparent.

Distribution.—Tasmania; and extra-tropical Australia from Rottnest Island in Western Australia to Port Curtis in Queensland

(*a.*) Subspecies **flammea** Q. & G.

Patelloida flammea Q. & G., *Voy. "Astrolabe," Zool.*, vol. 3, p. 354, 1834 (Hobart). *Acmaea flammea* (Q. & G.): Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 51, 1877; 1877, p. 45, 1878: Pilsbry, *Man. Conch.*, vol. 13, p. 57, pl. 37, f. 78–83, 1891: Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 15, p. 196, 1903. *Acmaea cantharus* (not Reeve): Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 215, 1906. *Acmaea mixta* (not Reeve): Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 39, p. 713, 1915.

When Quoy and Gaimard described *Patelloida flammea* they stated: "Il habite en abondance sur le bord de la mer, dans la rade de Hobart

Town, à Van Diemen. Nous le trouvames aussi sur l'île de Guam, dans l'archipel des Mariannes." Their figures can be matched quite well by the form commonly found in the intertidal belt of Blackmans Bay, near Hobart. Hedley (*Proc. Linn. Soc. N.S.W.*, vol. 39, p. 713, 1915) states that figs. 17–20 relate to a Guam species, assigns to it the name *flammea*, and uses *mixta* for the Tasmanian form. Such a proceeding is, I think, scarcely warranted. Quoy and Gaimard's description evidently refers to the Tasmanian shell, which occurs "en abondance." Further, there does not appear to be any evidence other than Quoy and Gaimard's statement that a species of Patelloididae occurs in Guam at all. Hedley has not named a species which falls a synonym to his usage of *flammea*. In any case, seeing that *flammea* has constantly been used for the Tasmanian species and no other, the proper course is to retain the name for it alone and to rename the Guam shells when authentic specimens are forthcoming.

Since the above was written I note that Iredale (*Proc. Linn. Soc. N.S.W.*, vol. 49, p. 234, 1924) comes to the conclusion that Quoy and Gaimard's name *flammea* should be retained for a Tasmanian species, but assigns it to the shell generally known as *septiformis*. I maintain, however, that my usage is correct, for the following reasons: Quoy and Gaimard's description and figures are far more applicable to the species traditionally accepted as *flammea* than they are to *septiformis*. The shape of the shell, with the apex high and sometimes subcentral, and the colour-pattern, both inside and outside, are characteristic of the species always regarded as *flammea*, and not of *septiformis*. All the figures can be matched quite well. Moreover, it is improbable that Quoy and Gaimard could have missed collecting *flammea*, which occurs abundantly on rocks near high-tide mark. The other species, *septiformis*, occurs under stones at low-tide mark, and, as the range of the tide at Hobart is only 4 ft. and low tide occurs only once in every twenty-four hours, it would more likely be the species to be overlooked. Further, Dr. Lamy has, at my request, examined the types of *Patelloida flammea*. They comprise six shells. Exteriorly five have brown and whitish rays, while one bears whitish flames. These characters are distinctive of Tasmanian examples of the shell here accepted as *flammea*. Interiorly five of the types are bluish except the central portion and have a dull border, and agree with pl. 71, fig. 17, of the "*Astrolabe*" *Atlas*. Such a type of coloration can be matched in shells of *flammea* with rayed exteriors, whereas in *septiformis* when a shell is rayed externally it is also rayed within, while the spatula in adult Tasmanian examples is usually little different from the remainder of the interior, and the outside is uniformly dark. One of the types shows a brownish interior on which are yellowish rays (like pl. 71, fig. 19, of the "*Astrolabe*" *Atlas*), and, comparing this with shells I sent him from near high-tide mark, Derwent Estuary, Tasmania, Dr. Lamy reports that this shell "rapproche le plus votre echantillon qui peut donc être rapporte au *P. flammea*." While, therefore, it is possible that Quoy and Gaimard's *Patelloida flammea* is a mixture of two species, I am convinced that some of the type specimens belong to the species here defined.

The first form of *flammea* that I recognize is that in which the shell is thin, moderately high, apex well forward, back slope slightly convex, front slightly concave. The colour outside is usually banded dark and light. Sometimes the bands are broken up into a zigzag pattern. The inside has a dark spatula; outside this it is generally lighter, with dark bands often showing a cross with broad rays amongst them. Shell usually smooth, sometimes with faint rounded ribs.

Bionomics.—Common in the Derwent Estuary, Tasmania, on rocks above half-tide mark. The shells are usually clean and well marked.

Distribution. — Tasmania: Derwent Estuary, Southport. South Australia: Robe, Macdonnell Bay. Victoria: Port Phillip, Cape Otway.

(*b.*) Subspecies **conoidea** Q. & G.

Patelloida conoidea Q. & G., *Voy.* "*Astrolabe,*" *Zool.*, vol. 3, p. 355, 1834 (King George Sound). *Acmaea conoidea* (Q. & G.): Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 198, 1912: Pilsbry, *Man. Conch.*, vol. 13, p. 53, pl. 37, f. 84, 85, 1891. *Patelloida conoidea* Q. & G.: Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916. *Patella insignis* Menke, *Moll. Nov. Holl. Spec.*, p. 34, 1843 (Western Australia). *Radiacmea insignis* (Menke): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924. *Patelloida mixta* (Reeve): Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916. *Acmaea flammea* (not Q. & G.): Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 198, 1912.

The shell described by Quoy and Gaimard was very high, the altitude (11 mm.) being nearly as great as the length (13 mm.) Verco (*Trans. Roy. Soc. S. Aust.*, vol. 36, p. 198, 1912) records shells of similar type but lower altitude from Ellensbrook and Rottnest Island, Western Australia, and suggests that Quoy and Gaimard's shell was probably a monstrosity, and that both it and Verco's own specimens are variants of *flammea.* On looking over eroded shells from various localities, one may easily find specimens which match Quoy and Gaimard's type in all characters save altitude. One of Verco's shells from Rottnest Island is fairly elevated, being 22 mm. in length and 18 mm. in height. I have little doubt then that Verco's surmise is correct, and that Quoy and Gaimard's *Patelloida conoidea* is an unusually high example of the common eroded Western Australian *flammea.* It certainly is not conspecific with the small Australian and Tasmanian species which have been referred to it.

The Western Australian form of *Chiazacmea flammea* may conveniently be kept as a subspecies. It is so regarded by Iredale, who applies to it Menke's name *insignis.* But if I am right in considering that Quoy and Gaimard's name *conoidea* refers to this form, then the synonymy will stand as above given. It apparently agrees with the first and third varieties mentioned by Verco in *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 213, 1906.

The subspecies *conoidea* is characterized by the moderately elevated form, arched slopes, broad radiating ridges, and crenulate margin. It is usually eroded, when the ridges may be obsolete. The colour shows radiating brown lines usually only evident on the margin, with the cross-pattern more or less indicated.

Distribution.—Western Australia from Rottnest Island southward and along south coast. South Australia: Robe.

(*c.*) Subspecies **mixta** (Reeve). (Text-fig. B.)

Patella mixta Reeve, *Conch. Icon.*, pl. 39, f. 129, 1855 (Port Phillip). *Acmaea jacksoniensis* var. *mixta* (Reeve): Pilsbry, *Man. Conch.*, vol. 13, p. 58, pl. 35 f. 32, 33, 1891. *Patelloida mixta* (Reeve): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 234, 1924. *Acmaea crucis* Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 52, 1877 (Tasmania). *Acmaea flammea* (Q. & G.): Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 212 (second and fourth varieties), 1906; vol. 36, pp. 183, 1912. *Acmaea inradiata* (not Reeve): Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 39, p. 712, 1915.

I have not seen the type, but Mr. Tomlin has lent me a specimen from Port Phillip which he states is extremely like the type. It is smooth outside with radiating brown marks and spots. Inside the spatula is dark

brown with a white centre; outside it is white with a yellowish margin. Brown rays, 1 in front and 3 or 4 behind, with short marginal ones at the side, indicate the *crucis* pattern. It is very similar to specimens from Wool Bay, South Australia.

The third form of *flammea* is a thick shell, smooth or with fine radiating ribs, high and with the apex more central than in the subspecies *flammea*. Outside, if uncorroded, it shows a dark cross on a light ground. Inside the spatula is dark with a white centre. Between the spatula and the margin it is white, with the rays of the cross dark brown. Many variations occur, and intermediates between this and other subspecies are common enough. It is distinguished from the subspecies *conoidea* mainly by the ribs being finer or absent and the frequent appearance of a well-defined cross.

Bionomics.—In the Derwent Estuary, Tasmania, this form occurs in the *Mytilus planulatus* association in the low-tide belt. The shells are generally eroded over the whole outer surface.

Distribution.—Tasmania; South Australia; Victoria.

(*d.*) Subspecies **cavilla** (Iredale).

Radiacmea insignis cavilla Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924.

This form shows the *crucis* pattern very clearly, but is distinguished from the subspecies *mixta* by its smaller size and regular close radiating ribs, about 50, with the interspaces narrower than the ribs. The ribs are finer than those of *conoidea* but coarser than those of *mixta*. Length, 13 mm. Iredale has named but inadequately described this subspecies, and has not indicated where the type specimen is deposited.

Bionomics.—Living on intertidal rocks ranging from near high-tide mark to low-tide mark, where I found it attached to shells of *Balanus*. Recorded by Iredale on shells of *Turbo stamineus* below low-tide mark.

Distribution.—New South Wales.

(*e.*) Subspecies **mimula** Iredale.

Patella jacksoniensis Reeve, *Conch. Icon.*, vol. 8, pl. 39, f. 127, 1855 (Port Jackson) (not *Patella jacksoniensis* Lesson). *Tectura jacksoniensis* (Reeve): Angas, *Proc. Zool. Soc.*, 1867, p. 220. *Acmaea jacksoniensis* (Reeve): Pilsbry, *Man. Conch.*, vol. 13, p. 58, pl. 42, f. 71–75, 1891. *Notoacmea mixta mimula* Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924.

This subspecies is about the same size as *cavilla*, but is smooth, with the outside usually eroded. Outside showing greenish and brown bands. Inside shining, with broad dark-brown and pale-yellow radiating bands.

Bionomics.—Intertidal in the *Ostrea cucullata* association, Sydney Harbour.

Distribution.—Sydney Harbour, N.S.W.; Blackmans Bay, Tasmania.

(*f.*) Subspecies **queenslandiae** n. subsp.

Description of type specimen, from Gladstone (in Dominion Museum): Shell conical, depressed, apex subcentral, slopes straight, plane of base arched, broadly elliptical. Outer surface smooth, eroded; interior—spatula porcellaneous, white with a few brown blotches, remainder shining, white, with about 16 radiating brown bands darkest at the margin and each consisting of several lines. Length, 14 mm; breadth, 11 mm.; height, 5·5 mm.

Bionomics.—Living on rocks between tides in the *Ostrea cucullata* association.

Distribution.—Gladstone, Port Curtis.

The present subspecies is close to *mixta*, differing in its broad depressed form, and in the greater amount of white in the interior. In some specimens the cross-pattern is indicated by the colour-bands at the ends and sides being darker than the others.

Chiazacmea mufria (Hedley).

> *Acmaea mufria* Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 39, p. 713, pl. 31, f. 50–52, 1915 (Sydney Harbour). *Radiacmea mufria* (Hedley): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924.

This little species has a narrow elevated shell with 20 to 30 low broad ribs. It is buff irregularly rayed with brown. Length, up to 8 mm.

The shell in form and texture somewhat resembles that of *Chiazacmea flammea* subsp. *mixta*, hence I have placed it near that species. The characters of the radula are unknown.

Bionomics.—Living among the annelid *Galeolaria caespitosa* between tide-marks, Middle Harbour, Port Jackson.

Distribution.—New South Wales: Balmoral Beach, Middle Harbour, Wreck Bay, Twofold Bay.

Chiazacmea heteromorpha n. sp. (Plate 99, fig. 1; and text-fig. C.)

Description of type specimen from Facing Island (type in Dominion Museum): Shell elevated, conical, apex a little in advance of the centre, the sides convex, the anterior slope considerably steeper than the posterior, the surface rough, the apical portion eroded, but no ribs. Colour of uneroded portion dark brown. Margin irregular in outline, narrowed in front, and truncated anteriorly and posteriorly, the right side expanded behind the apex, the left side fairly regular. Plane of base irregular, evidently in adjustment to the rock-surface. Interior margin glossy, spatula porcellaneous. Spatula white with a brownish centre, margin jet-black, between these pale bluish-brown crossed by 6 broad black bands. Length, 18 mm.; breadth, 16 mm.; height, 8 mm.

Range of variation: This species undergoes remarkable changes in its life-history. The young shell is perfectly regular in form, narrowed in front, apex in the anterior third, sides straight, finely ribbed, yellow with 8 broad black rays. Spatula dark brown. As growth proceeds the margin expands irregularly in adjustment to the irregularities of the rock-surface, and the original regular young shell becomes the eroded apex of the adult. The colour-bands can be distinguished only in the marginal area of the inside, and occasionally on the outside. Generally the anterior 3 bands of the young shell, which are narrower than the others, are displaced by a single broad band in the adult shell, thus giving 6 as the normal number of the adult. The spatula is sometimes obscurely rayed or spotted with brown. Half-grown shells clearly show the changing characters.

Description of radula: Centrals with long narrow blunt-pointed cusps. Inner laterals with broad rounded cusps; outer laterals with narrow rounded cusps. Marginals with broad cusps projecting inwards.

Bionomics.—Living on rocks between tide-marks in the *Ostrea cucullata* association and above.

Distribution.—Facing Island, Queensland.

Genus ASTERACMEA n. gen.

Shell minute, translucent, apex subcentral or anterior, sides straight or slightly arched, smooth or with minute radiating striae. In most species the shells have radiating pink bands. Type: *Helcioniscus illibrata* Verco.

The radula of *A. illibrata* has the formula 2.2.2.2.2. Centrals approximate, laterals posterior and in a row, the inner larger than the outer, marginals narrow.

The five species I have grouped together under the above name seem to be allied. The only one in which the animal is known is named as type. The characters of the radula and shell bring it clearly within the family Patelloididae. Verco states that his *illibrata* has an incomplete branchial cordon, nothing being said of a plume. I have, however, in placing the genus *Asteracmea* near *Patelloida* relied on the radula characters which are fully described and figured.

The species range down to 100 fathoms, and are found from Western Australia to New Zealand.

Asteracmea illibrata (Verco).

Shell small, conical, smooth, apex central or subcentral, usually with 8 pink rays on the lower half of the shell.

Distribution.— Western Australia; South Australia; New South Wales; Tasmania.

(*a*.) Subspecies **illibrata** (Verco).

> *Helcioniscus illibrata* Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 205, pl. 10, f. 6–14, 1906 (Spencer Gulf); *l.c.*, vol. 36, p. 181, 192, 1912.

Shell nearly as high as long, apex central, pink with 8 white rays on the lower half.

Distribution.—Western Australia: King George Sound, Ellensbrook, Yallingup, Bunbury, Rottnest Island. South Australia: Spencer Gulf; south of Cape Wills (100 fathoms); off St. Francis Island (15–20 fathoms).

(*b*.) Subspecies **mellila** (Iredale).

> *Notoacmea suteri* (not Iredale): May, *Proc. Roy. Soc. Tas.*, 1915, p. 78; *Check-list Moll. Tas.*, p. 47, pl. 22, f. 12, 1921. *Parvacmea illibrata mellila* Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 242, 1924 (Tasmania).

Shell moderately elevated, apex in front of the centre, usually with 8 pink rays. Differs from the subspecies *illibrata* in the lower altitude and less centrally placed apex.

Distribution.—Tasmania; Twofold Bay, Sydney, N.S.W.

Asteracmea suteri (Iredale).

> *Acmaea roseoradiata* Suter, *Proc. Mal. Soc.*, vol. 7, p. 317, pl. 27, f. 9, 10, 1907 (Port Pegasus, Stewart Island; type in Wanganui Museum); *Man. N.Z. Moll.*, p. 65, pl. 5, f. 8, 1913 (not *A. roseoradiata* Smith). *Notoacmea suteri* Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 428, 1915 (new name for *A. roseoradiata* Suter).

Shell elevated, conical, apex subcentral, upper portion with subobsolete radiate striae, lower portion with indistinct low riblets. Pink with 10 broad white rays on lower portion. This species appears to differ from *A. illibrata* in having 10 pink rays.

Distribution.—New Zealand: Port Pegasus (18 fathoms), Dusky Sound (30 fathoms), off Taumaki Island (10 fathoms), Snares (50 fathoms).

Asteracmea crebrestriata (Verco).

Nacella crebrestriata Verco, *Trans. Roy. Soc. S. Aust.*, vol. 28, p. 144, pl. 26, f. 20, 21, 1904; *l.c.*, vol. 30, p. 208, 1906; *l.c.*, vol. 36, pp. 183, 195, 1912. *Nacella crebrestriata* Verco var. *roseoradiata* Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 195. 1912 (Guichen Bay, S. Aust.).

Shell moderately elevated, apex subcentral, numerous radial riblets. Translucent, with white markings or 15–16 pink radiating bands.

Distribution.—Western Australia: King George Sound, Yallingup, Rottnest Island. South Australia: off Cape Borda (55 fathoms), Port Sinclair, St. Francis Island, Guichen Bay.

Asteracmea stowae (Verco).

Nacella stowae Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 209, pl. 10, f. 4, 5, 1906; *l.c.*, vol. 36, pp. 183, 195, 1912.

Shell depressed, apex anterior, numerous fine radiating striae, translucent, with 16 pink radiating bands.

Distribution.—Western Australia: King George Sound, Bunbury, Rottnest Island. South Australia: Kingston, St. Francis Island, Port Macdonnell, Kings Point.

Asteracmea axiaerata (Verco).

Patella axiaerata Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 193, pl. 15, f. 3, 4, 1912 (Rottnest Island). (Type in Verco's collection.)

Shell conical, smooth, apex subcentral, height about half the length, white with 10–18 yellow radial bands with golden axial hair-lines in them.

Distribution.—Western Australia: King George Sound, Rottnest Island.

Genus Radiacmea Iredale.

Radiacmea Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 427, 1915. Type: *Acmaea cingulata* Hutton.

This genus may be defined as including those species possessing radially-ribbed porcellaneous shells and radulae with the formula 0.2.2.2.0. The teeth of *Radiacmea rubiginosa*, the only species in which the radula is known, are short and blunt-pointed, the centrals are in juxtaposition and in advance of the laterals, which are nearly of equal size and in two pairs, the outer pair being posterior to the inner. They are thus disposed in two rows diverging posteriorly from the centrals.

Conchologically the species are not to be distinguished from those of *Patelloida*, which have regularly-ribbed shells. The teeth, however, are quite different, and recall in disposition those of *Tectura*.

Radiacmea comprises 3 species from the New Zealand area, ranging from the Bay of Islands and the Chatham Islands southward to Macquarie Island.

Radiacmea inconspicua (Gray).

Radiacmea inconspicua is distinguished by the radiating ribs with wide interspaces. About 20 reach the apex, but at the margin there may be double this number. The position of the apex and the contour of the base differs in the two subspecies. Colour inside pinkish, the centre whitish or greenish; usually there are radiating bifurcating lines of a darker pink.

Description of radula from a specimen from Lyall Bay, Cook Strait: The radula-plates are rectangular with the outer and anterior sides sinuated.

The teeth, one pair of centrals and two of laterals, arranged in two diverging rows, the centrals being in contact and the outer laterals wide apart. Cusps short and blunt, all of nearly equal size.

Distribution.—New Zealand, from the Bay of Islands and Little Barrier Island southwards to Otago Peninsula ; Chatham Islands.

(*a.*) Subspecies **inconspicua** (Gray).

Patella inconspicua Gray, in Dieffenbach's *Travels N.Z.*, vol. 2, p. 244, 1843 (type in British Museum). *Radiacmea inconspicua* (Gray): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 237, 1924. *Acmaea cingulata* Hutton, *N.Z. Jour.*, vol. 1, p. 477, 1883 (Dunedin; type in Canterbury Museum); *Trans. N.Z. Inst.*, vol. 16, p. 215, pl. 11, f. 5 (radula), 1884; *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 372, 1884: Pilsbry, *Man. Conch.*, vol. 13, p. 53, 1891: Suter, *Proc. Mal. Soc.*, vol. 7, p. 316, pl. 27, f. 3–5, 1907; *Man. N.Z. Moll.*, p. 63, pl. 5, f. 6, 1913. *Acmaea rubiginosa* (Hutton): Iredale, *Trans. N.Z. Inst.*, vol. 40, p. 376, 1908: Bucknill, *Sea-shells N.Z.*, p. 13, pl. 5, f. 7, 1924.

Shell usually depressed, elliptical, often narrowly so, apex about the anterior fourth. About 25-30 principal ribs, usually with 1 or 2 smaller ribs in each interspace towards the periphery, also with concentric growth-striae

I have found very little variation in the shell other than in the intensity of the pink colouring, which varies from a brownish-pink in some young shells through lighter shades.

The animal is white, the foot yellowish, the mouth orange. The edge of the mantle shows more or less green, darkest behind the head. On removing the shell the buccal mass is pink and the visceral mass deep green.

Bionomics.—The subspecies *inconspicua* is fairly common on the coralline-covered rock-surfaces in the brown-algae formation, and on the shells of *Haliotis iris* and *H. australis* in the low-tide belt. It is easily overlooked, as the shells are invariably covered with a growth of pink *Melobesia* with sometimes tufts of *Corallina* in addition. On removing the shell it is found that it exactly fits in the depression in the surrounding *Melobesia*, which covers the rock or *Haliotis* shell.

Distribution.—Bay of Islands (Suter); Little Barrier Island; Mount Maunganui; East Cape (Suter); Cook Strait; Banks Peninsula; Otago Peninsula; Shag Point; Taumaki Island, in 10 fathoms (Suter); Taieri Beach.

(*b.*) Subspecies **rubiginosa** (Hutton).

Fissurella rubiginosa Hutton, *Cat. Marine Moll. N.Z.*, p. 42, 1873 (Chatham Islands). *Patella rubiginosa* Hutton, *Jour. Conch.*, vol. 26, p. 38, 1878; *Man. N.Z. Moll.*, p. 110, 1880. *Acmaea rubiginosa* Hutton, *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 372, 1884: Suter, *Proc. Mal. Soc.*, vol. 7, p. 315, pl. 27, f. 1, 2, 1907: Suter, *Man. N.Z. Moll.*, p. 65, pl. 5, f. 9, 1913. *Glyphis rubiginosa* (Hutton): Pilsbry, *Man. Conch.*, vol. 12, p. 216, 1890.

In the type collection in the Dominion Museum are three specimens from the Chatham Islands. None agree in measurements with Hutton's description. One specimen, however, a water-worn and bleached shell, has an anterior callus partly detached, while the apex outside is worn through. This may have led Hutton to place the species in the genus *Fissurella*. Hutton afterwards transferred it to *Patella*.

Shell moderately elevated, broadly elliptical, apex subcentral to the anterior third, acute. About 20 principal ribs with 1 or 2 smaller ribs in each interspace towards the periphery, also with concentric growth-striae.

This subspecies differs from the New Zealand form in its broader outline, more central apex, more elevated form, and more prominent ribs. These,

however, being variable characters in each subspecies, I class both under the same species.

The largest shell I have seen measures 17 mm. in length.

Bionomics.—Young specimens were found living under stones in rock-pools at Red Bluff.

Distribution.—Chatham Island.

Radiacmea intermedia (Suter).

Acmaea intermedia Suter, *Proc. Mal. Soc.*, vol. 7, p. 316, pl. 27, f. 6–8, 1907 (near Bounty Islands, in 50 fathoms); *Man. N.Z. Moll.*, p. 64, pl. 5, f. 7, 1913.

Only known from dead shells, and from one locality. It appears to be allied to *R. macquariensis*, a species which I have not seen, but of which Hedley has published a good description and figure.

The shells are small, up to 11 mm. in diameter, conical, with the apex at the anterior third, and with 25-50 fine radiating riblets. It is light-brownish with white ribs and a dark spatula.

Radiacmea macquariensis Hedley.

Radiacmea macquariensis Hedley, *Rep. Aust. Ant. Exp., Zool.*, vol. 4, pl. 1, p. 41, 1916.

Found on intertidal rocks, Macquarie Island, by Mr. H. Hamilton. Hedley compares this species with *campbelli* of Filhol, but that species, as proved by the radula, belongs to a different genus.

The main characters of *Radiacmea macquariensis* are the regularly conical form with the apex about the anterior third, the numerous (about 60) depressed radial riblets, and the pinkish coloration. Length, 12 mm.

Genus NACCULA Iredale.

Naccula Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 328, 1924. Type: *Patelloida punctata* Q. & G.

Naccula comprises a single species characterized by its small hyaline shell with anterior apex, and especially by the radula, which has the cutting-edges of the teeth in two diverging lines. Teeth 0.2.2.2.0.

Iredale's guess that this species would form a distinct genus has proved to be correct, though his method of founding new names under such circumstances can scarcely be called scientific.

Distribution.—Western Australia, South Australia.

Naccula punctata (Q. & G.).

Patelloida punctata Q. & G., *Voy. "Astrolabe," Zool.*, vol. 3, p. 365, pl. 71, f. 40–42, 1834 (King George Sound): Hedley, *Jour., Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916. *Acmaea punctata* (Q. & G.): Pilsbry, *Man. Conch.*, vol. 13, p. 59, pl. 77, f. 89, 1891: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 214, 1906 (this record doubtful—the radial sculpture suggests that the shells were the young of *N. septiformis*). *Nacella parva* Angas, *Proc. Zool. Soc.*, 1878, p. 862, pl. 54, f. 12 (South Australia): Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 208, 1906; *l.c.*, vol. 36, pp. 183, 194, 1912. *Nacella compressa* Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 208, pl. 8, f. 11, 12, 1906 (Investigator Strait, S. Aust.). *Naccula punctata* (Q. & G.): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 238, 1924.

Shell depressed, apex forward, anterior slope concave, posterior convex, smooth or with fine concentric growth-lines. Horn-colour with an axial line of blue spots. Ratio of width to length variable.

Radula: Centrals and inner laterals having the cusps with broad cutting faces in two lines diverging from the centre of the radular ribbon to each side, thus apparently forming a scraping organ. Outer laterals small.

Bionomics.—Living on *Zostera*, Lucky Bay.

Distribution.—Western Australia: King George Sound, Lucky Bay, Bunbury, Geographe Bay, Fremantle. South Australia: Holdfast Bay, Aldinga Bay, Fowler's Bay, Scales Bay, St. Francis Island, Investigator Strait.

Verco dredged specimens at various depths down to 35 fathoms, but does not state whether they were living or not.

Genus ACTINOLEUCA n. gen.

High conical shells with straight sides and subcentral apex. Finely and evenly ribbed. Texture of shell porcellaneous throughout like that of *Radiacmea*. In the radula of *A. campbelli* the lateral teeth are in a transverse row posterior to the centrals. Type: *Patella campbelli* Filhol.

The species here associated form a well-defined and distinct group approaching *Radiacmea* in shell-characters and *Notoacmea* in the disposition of the teeth of the radula. One is a deep-water form whose animal has not yet been described, another is a littoral species, the third is an Oligocene fossil.

Actinoleuca campbelli (Filhol). (Text-fig. D.)

Patella campbelli Filhol, *Compt. Rend.*, vol. 91, p. 1095, 1880 (Campbell Island; type in Mus. His. Nat. Paris): *Miss. Is. Camp.*, p. 530, 1885. *Acmaea campbelli* (Filhol): Suter, *Proc. Mal. Soc.*, vol. 7, p. 321, pl. 27. f. 19-21, 1907; *Man. N.Z. Moll.*, p. 66, pl. 5, f. 10, 1913: Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924.

Notoacmea campbelli is related to *N. calamus*. It is, however, a much smaller shell, uniformly pink in colour. It is an elevated conical species with an acute apex. The sculpture consists of numerous fine radiating riblets.

Radula: Centrals approximate, with short rounded cusps; laterals similar in shape and size to the centrals.

Bionomics.—*Actinoleuca campbelli* is found living on shells of *Cantharidus pruninus*, which lives on seaweed growing on coastal rocks at Ross Island, Auckland Islands. Odhner records this species from Campbell Island as on *Macrocystis*.

Distribution.—Campbell Island; Auckland Islands.

Actinoleuca calamus (Crosse and Fischer).

Patella calamus Crosse and Fischer, *Journ. de Conch.*, 1864, p. 348; 1865, p. 42, pl. 3, f. 7, 8 (Port Lincoln, South Australia). *Acmaea calamus* (C. & F.): Angas, *Proc. Zool. Soc.*, 1865, p. 186: Pilsbry, *Man. Conch.*, vol. 13, p. 54, pl. 37, f. 3, 4, 1891: Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 15, p. 197, 1903: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 211, 1906; vol. 36, pp. 184, 199, 1912. *Acmaea calamus* (C. & F.) var. *polyactina* Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, p. 184, pl. 15, f. 1, 2, 1912 (Gulf St. Vincent). *Patelloida calamus* (C. & F.): Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916: May, *Check-list Moll. Tas.*, p. 46, pl. 22, f. 2, 1921. *Radiacmea calamus* (C. & F.): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 236, 1924.

A well-marked species, distinguished by the high conical form, subcentral acute apex, straight sides, and very fine radiating riblets. White, more or

less ornamented with brown spots or radiating bands. Some shells are chestnut-brown.

Distribution.—Verco records this species as taken alive in Spencer Gulf, South Australia, at depths ranging from 5 to 17 fathoms. It is apparently not uncommon in shallow water off the south coast of Australia, from Western Port, Victoria, to Geraldton, Western Australia. Also found in Tasmania, and at Twofold Bay, New South Wales.

Actinoleuca multiradialis (Chapman and Gabriel).

Patelloida multiradialis Chapman and Gabriel, *Proc. Roy. Soc. Vict.*, vol. 36, p. 24, pl. 1, fig. 4, 3, fig. 29, 1923.

This species is stated to be an ally of *A. calamus*, differing in the more depressed form of the shell, rounder outline, and more scaly character of the ribs.

Distribution.—Victoria: Balcombian (Oligocene), towards the upper part of the Clifton Bank.

Genus Notoacmea Iredale.

Notoacmea Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 428, 1915. Type: *Patelloida pileopsis* Q. & G.

Notoacmea may be defined as including those species possessing shells having the inner layer thin and hyaline, and the outer (when present) more shelly. The apex is usually forward, and the posterior slope convex. Besides the characters of the shell, they are especially distinguished by the radula, in which the centrals and inner laterals are generally long, curved, and pointed, and stand erect in the basal ribbon. The outer laterals are usually small and apparently functionless.

The genus comprises species distributed over the shores of southern and eastern Australia, Tasmania, and New Zealand. It occurs chiefly in the intertidal belt, ranging from the upper limit of the waves to low-tide mark.

The species here included in the genus *Notoacmea* may be ranged under five subgeneric groups—*Notoacmea*, *Parvacmea*, *Conacmea*, *Thalassacmea*, and *Subacmea*.

Subgenus Notoacmea Iredale.

Shell with the apex well forward, the posterior slope convex, the anterior straight. The inner layer generally translucent porcellaneous, the outer of a coarser texture and dark-coloured, usually tessellated.

Notoacmea (Notoacmea) pileopsis (Q. & G.).

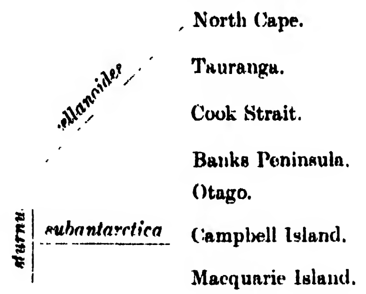
As a species *Notoacmea pileopsis* may be defined as including shells of elliptical shape, forward apex, sometimes situated above the anterior margin, concave anterior slope, the highest point being behind the apex. The shells may be quite smooth except for concentric growth-lines, or have fine radiating lines or prominent ribs.

Outside the colours are brown and green, tessellated; inside the spatula is dark brown, surrounding this it is bluish-white, while the border is dark brown, more or less marked with yellow.

In the radula (in the subspecies *sturnus*) the centrals have long bases and long pointed cusps projecting at right angles to the basal plate; the inner laterals have also long projecting pointed cusps; the outer laterals are small.

Notoacmea pileopsis is a decidedly dimorphic and less markedly polymorphic species. So different are its forms that it is difficult to believe the two found in the northern portion of New Zealand belong to the same species. Suter, indeed, included the species in three places in his *Manual.* Yet one form may be found passing into another under environmental changes. The form with prominent ridges appears to be but an epharmonic varient of the one with fine lirae.

Reviewing the subspecies in connection with their geographical distribution, it will be observed that from the *sturnus* form they differentiate from south to north into two other very distinct types. It is as though the original form of the species was the smooth *sturnus* type, with its headquarters in Otago and its outposts extending northwards to Waipara and southward to Macquarie Island. A small section in Campbell Island developed distant radiating lirae. From Banks Peninsula northward the species developed close radiating lirae, with the shells increasing in size and relative width towards the north. In exposed situations this form developed strong ribs, an obvious device to strengthen the shell. This ribbed form then appears to have developed along a line of its own parallel to that of its parent, so that in all characters except the general type of coloration the subspecies *pileopsis* and *cellanoides* are perfectly distinct. Their habitats, too, are different. This interpretation of the course of evolution of the forms of *pileopsis* may be expressed diagramatically as under :—



(*a.*) Subspecies pileopsis (Q. & G.).

Patelloida pileopsis Q. & G., *Voy.* "*Astrolabe,*" *Zool.*, vol. 3, p. 359, pl. 71, f. 25–27, 1924 (Bay of Islands): Deshayes, in Lamarck's *Hist. Nat. Anim. s. Vert.*, ed. 2, vol. 7, p. 550, 1836. *Tectura pileopsis* (Q. & G.): Hutton, *Cat. Marine Moll. N.Z.*, p. 43, 1873; *Jour. de Conch.*, vol. 26, p. 36. *Acmaea pileopsis* (Q. & G.): Hutton, *Man. N.Z. Moll.*, p. 88, 1880: Pilsbry, *Man. Conch.*, vol. 13, p. 57, pl. 37, f. 90–92, 1891: Suter, *Proc. Mal. Soc.*, vol. 7, p. 319, pl. 26, f. 15–16, 1907; *Man. N.Z. Moll.*, p. 71, pl. 7, f. 4, 1913: Hutton, *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 373, 1884: Bucknill, *Sea-shells N.Z.*, p. 13, pl. 5, f. 6, 1924.

The subspecies *pileopsis* is narrowly to broadly elliptical, depressed when young, but old specimens become considerably elevated through the downward growth of the margins. The surface is finely and closely radiating lirate. Outside dark, tessellated or radiately marked; inside—spatula dark brown surrounded by bluish-white, margin black with few yellow markings. Length, 28 mm.; breadth, 25 mm.; height, 12 mm. (specimen from Mount Maunganui).

Bionomics.—This subspecies is common in the upper portion of the intertidal belt. The shells are rather thin, with sharp edges, and are usually found in crevices or under ledges—that is, in sheltered places.

Sometimes they are found above the limits of ordinary high tides. Suter states that they are found in stations protected from rain: this may be so, but it is probable that it is the drying effect of exposure to the sun that the animal endeavours to avoid. The largest shells I have always found in sheltered situations, and in these stations the shells are the least eroded. The shells found on the exposed rocks of Island Bay, Cook Strait, are small, generally under 15 mm. in length, dark-coloured within and without, and with the greater portion of the outer surface eroded. Specimens from Crater Bay, White Island, near where a stream containing hydrochloric acid enters, have thick shells with the outer surface much eroded.

May named and figured but did not describe this species. No mention is made of a type specimen.

Distribution.—Common on the coast as far south as Banks Peninsula: Tom Bowling Bay, Bay of Islands, Little Barrier Island, Mount Maunganui, Cook Strait, Maunganui Bluff, Manukau Head, Raglan, Stephen Island, Waipara, Banks Peninsula.

(*b.*) Subspecies **sturnus** (Hombron and Jacquinot).

Patella sturnus H. & J., *Ann. Sci. Nat.*, ser. 2, vol. 16, p. 191, 1841. *Patelloida antarctica* H. & J., *l.c.*, p. 192, 1841 (Auckland Island): Pilsbry, *Man. Conch.*, vol. 13, p. 157, 1891. *Patella cantharus* Reeve, *Conch. Icon.*, vol. 8, pl. 40, p. 131, 1855 (New Zealand).* *Nacella cantharus* (Reeve): Hutton, *Cat. Marine Moll. N.Z.*, p. 46, 1873. *Tectura cantharus* (Reeve): Hutton, *Jour. Conch.*, vol. 26, p. 36. *Acmaea cantharus* (Reeve): Hutton, *Man. N.Z. Moll.*, p. 88, 1880: Pilsbry, *Man. Conch.*, vol. 13, p. 55, pl. 37, f. 1, 2, 1891: Suter, *Proc. Mal. Soc.*, vol. 7, p. 320, pl. 27, f. 17–18, 1907: Iredale, *Trans. N.Z. Inst.*, vol. 40, p. 376, 1908: Suter, *Man. N.Z. Moll.*, p. 66, f. 1, 1913: Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924: Bucknill, *Sea-shells N.Z.*, p. 11, 1924. *Acmaea pileopsis* (Q. & G.): Hutton, *Trans. N.Z. Inst.*, vol. 15, p. 127, pl. 15, f. M. (dentition), 1883: Iredale *Trans. N.Z. Inst.*, vol. 47, p. 429, 1915: Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924.

Shell narrow-elliptical, the posterior slope uniformly curved so that the shell is neither so depressed when young nor so elevated when old as in the subspecies *pileopsis*. Surface smooth except for connected growth-lines. Outside conspicuously tessellated, margin inside yellow and black. Length, 25 mm.; breadth, 19 mm.; height, 10 mm. (Shag Point).

Bionomics.—Common on rocks in the upper half of the intertidal belt, ascending above high-tide mark in damp situations exposed to sea-spray.

Distribution.—South coast of Banks Peninsula, Shag Point, Otago Peninsula, Stewart Island, Snares (Suter), Auckland Island, Campbell Island, Bounty Island, Macquarie Island, Preservation Inlet (Bucknill).

(*c.*) Subspecies **cellanoides** n. subsp. (Plate 99, fig. 2.)

Description of type from Little Barrier Island (in the Dominion Museum): Shell narrow-elliptical, slightly irregular in outline. Anterior slope concave, posterior arched, apex the highest or nearly the highest point. The whole shell strongly radiately ribbed, 28 to 36 in number, those on posterior slope being largest. Outside tessellated green and brown; inside—spatula

* This name has been generally used for a species found in Tasmania. Iredale in 1908 pointed out (*Trans. N.Z. Inst.*, vol. 40, p. 376) that it refers to a New Zealand species and is a synonym of the species *pileopsis*. There can be little doubt as to the correctness of Iredale's conclusion; in fact, he has since confirmed it by an examination of the type specimen. Reeve's figure agrees with the New Zealand form, and differs from the Tasmanian shell in practically every point that separates the New Zealand and Tasmanian forms.

dark brown surrounded by bluish-white, margin dark brown with yellow cross-bands.

From Cook Strait to Banks Peninsula this form appears to be merely a variant of *pileopsis*, differing only in the possession of ribs, and occurring with the species. In the north, however, it differs entirely from the typical form at all stages of growth, and occurs on exposed rocks, while *pileopsis* proper occurs in sheltered situations.

Bionomics.—The subspecies *cellanoides* in the northern portion of New Zealand, with its thickened shell with strong ridges, is well adapted to live in exposed situations. It is found in the barnacle formation from half-tide mark upwards. At White Island, under the influence of hydrochloric acid, it assumes a large size (length, 23 mm.) with much eroded shells. In my paper on "Marine Littoral Plant and Animal Communities," published in *Trans. N.Z. Inst.*, vol. 54, 1923, I have referred to this form as *Notoacmea septiformis.*

Distribution.—Tom Bowling Bay, Bay of Islands, Little Barrier Island, Taranga Island, Mount Maunganui, White Island, Stephen Island, Waipara, Taylor's Mistake.

(*d.*) Subspecies **subantarctica** n. subsp.

Acmaea septiformis (not Q. & G.): Suter, *Man. N.Z. Moll.*, p. 72, 1913. *Acmaea helmsi* (not Smith): Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924.

The above records from the Auckland and Campbell Islands probably refer to this subspecies.

Description of type from Campbell Island (in the Canterbury Museum): Shell thin, narrow-elliptical, apex in anterior fourth, posterior slope convex, anterior concave. Surface smooth, with fine low distant radiating lirae on posterior slope. Colour dark brown finely tessellated with lighter, inside uniformly dark shining bluish-black. Length, 11 mm.; breadth, 8 mm.; height, 4 mm.

Distribution.—Campbell Island; Auckland Island (as quoted above).

Notoacmea (Notoacmea) mayi May.

Acmaea cantharus (not Reeve): Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1877, p. 45, 1878. *Notoacmea mayi* May, *Illus. Index Tasmanian Shells*, p. 100, pl. 22, f. 3, 1923.

May named and figured but did not describe this species. No mention is made of a type specimen.

Shell ovoid, narrowing in front where it is obtusely pointed, depressed, the dorsal surface arched from apex to posterior border. Highest point in advance of centre. Apex at front margin or just above, and in advance of it when anterior slope is concave. The greatest distance observed between apex and anterior margin, in a shell 14 mm. in length, was 2 mm. Upper surface with concentric growth-lines only. Colour above creamy-white reticulated with dark-brown streaks of varying thickness. Inside dark brown, lighter round spatula and along margin where it is cross-banded with yellow.

Largest specimen seen (from Frederic Henry Bay, Tasmania): Length, 19·5 mm.; breadth, 15 mm.; height, 5 mm.

Notoacmea mayi is allied to *N. pileopsis* of New Zealand, differing from the subspecies *sturnus* in possessing a marginal or submarginal apex, in being more depressed, in the anterior portion of the shell being more pointed, and generally in having more ground-colour on the upper surface.

It is much smaller than the New Zealand form. It is perhaps a derivative of *pileopsis*, and might with propriety be regarded as one of the subspecies of that species.

Bionomics.—Occurs commonly in the upper portion of the intertidal belt on rocks. The apex and the greater portion of the upper surface are generally eroded. As in other species, a darkening of the inside colour corresponds with the eroded areas.

Distribution.—South-east Tasmania: Derwent Estuary and Frederic Henry Bay. Victoria: Port Fairy (Iredale).

Notoacmea (Notoacmea) septiformis (Q. & G.).

Notoacmea septiformis is an easily circumscribed species. It is very variable in coloration, but readily recognized by its form and sculpture. It is broadly elliptical, usually depressed, with apex in front fourth or sometimes in young shells quite near anterior margin. Posterior slope convex, anterior slightly concave. Shell quite thin with an acute margin. Upper surface with close very fine granulose radiating ribs, interspaces wider than ribs. In some cases ribs are obsolete. Prevailing colours outside are green and brown; some shells are entirely white. Usually the colours are tessellated, sometimes rayed. Inside is a bluish-white with a vaguely marked brown spatula and a rather broad margin, dark brown in dark shells and light brown or yellow with whitish rays in light-coloured shells.

Notoacmea septiformis is a close relation of *N. pileopsis* of New Zealand.

The radula was examined in specimens collected at Corny Point, South Australia. Centrals approximately long, narrow, with long projecting pointed cusps. Outer laterals small. Teeth horn-colour with dark-brown cusps.

I find it difficult to define subspecies. Certain it is that great variation exists in shape and coloration, and the form from King George Sound appears at first sight different from the more elevated specimens from Victoria and Tasmania, but at Kangaroo Island a series proves that a depressed form may develop into a more elevated form. The same is witnessed in a series from Adventure Bay, Tasmania, though in the young the apex is more forward than it is in Western Australian examples. From comparisons such as these I concluded that a single variable species ranges along the coast of southern Australia and Tasmania. Dr. Lamy informs me that a Tasmanian specimen which I sent him is the same species as Quoy and Gaimard's type from Western Australia.

(*a.*) **Subspecies septiformis (Q. & G.).**

Patelloida septiformis Q. & G., *Voy.* "*Astrolabe,*" *Zool.*, vol. 3, p. 362, pl. 71, f. 43, 44, 1834 (King George Sound, W. Aust.): Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916: Desh. & M.-Edw. in Lam, *Anim. s. Vert.*, 2nd ed., vol. 7, p. 550, 1836. *Acmaea septiformis* (Q. & G.): Pilsbry, *Man. Conch.*, vol. 13, p. 55, pl. 37, f. 93, 94, 1891: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 36, pp. 184, 199, 1912.

The subspecies *septiformis* is characterized by the shell being comparatively thick, depressed, radiating lirae not well marked, sometimes obsolete, and by the colours in the young shells being predominantly light yellows and browns. The type figured by Quoy and Gaimard was black with brown radiating bands; inside bluish-white with black margin and brown spatula.

Distribution.—Western Australia: King George Sound, Ellensbrook, Yallingup. South Australia: Corny Point.

(*b.*) Subspecies **scabrilirata** (Angas).

> *Acmaea septiformis* (Q. & G.): Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 50, 1877: Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 15, p. 195, 1903: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 215, 1906. *Acmaea scabrilirata* Angas, *Proc. Zool. Soc.*, 1865, p. 154 (Port Lincoln): Pilsbry, *Man. Conch.*, vol. 13, p. 56, 1891. *Tectura scabrilirata* Angas, *Proc. Zool. Soc.*, 1867, p. 220. *Notoacmea flammea* (not Q. & G.): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924 (including n. subsp. *diminuta*).

The distinguishing features of Angas's species are essentially those of *N. septiformis*. In no other Australian species of Patelloididae does the sculpture consist of " extremely slender riblets, each of which is surmounted by a series of minute granules."

Mr. Tomlin informs me that the type specimen is very depressed. As it is only 12 mm. in length, it is probably a young shell.

The subspecies *scabrilirata* is distinguished by the thin shell with a ring of bluish-white callus within, with the highest point sometimes behind the apex, radiating lirae well marked, and by the colouring being often dark. Young shells are usually much depressed, but the adults are moderately elevated. The apex is relatively more advanced in young shells than in adult. The most elevated shell I have seen comes from Cape Schanck, Victoria: length, 12 mm.; height, 4·6 mm. The largest specimen examined was collected on King Island: length, 23 mm.; height, 6·5 mm.

Bionomics.—In the Derwent Estuary, Tasmania, this subspecies is found abundantly under stones just above low-tide mark. Like many other limpet-like species with delicate shells, it prefers smooth stones.

Distribution.—South Australia, Victoria, and Tasmania, on the coast generally. Kangaroo Island, King Island. New South Wales as far north as Sydney.

The validity of the two following species is doubtful.

Patelloida elongata Q. & G.

> *Patelloida elongata* Q. & G., *Voy.* " *Astrolabe*," *Zool.*, vol. 3, p. 358, pl. 71, f. 12–14, 1834: Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 35, 1916. *Acmaea elongata* (Q. & G.): Pilsbry, *Man. Conch.*, vol. 13, p. 59, pl. 37, f. 86, 87, 1891.

This species does not appear to have been collected since its discovery, nor is there anything in the description to separate if from the young of *N. septiformis*.

Acmaea subundulata Angas.

> *Acmaea subundulata* Angas, *Proc. Zool. Soc.*, 1865, p. 155 (Port Lincoln, S. Aust.). *Tectura subundulata* Angas, *Proc. Zool. Soc.*, 1867, p. 220. *Acmaea subundulata* Angas: Pilsbry, *Man. Conch.*, vol. 13, p. 57, 1891: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 214, 1906; vol. 36, pp. 185, 189, 1912. *Patelloida subundulata* (Angas): Hedley, *Jour. Roy. Soc. W. Aust.*, vol. 1, p. 36, 1916: Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 236, 1924.

I know nothing of this species, and Iredale's note does not help to establish its validity. It has been recorded by Verco from several South Australian localities. The specimens were identified from Angas's " types," but Iredale states that the three shells marked types belong to as many species. I suspect it to be a form of *Notoacmea septiformis*.

Mr. J. R. Le B. Tomlin, to whom I applied for information on the type of *subundulata*, states that "there are two lots in the British Museum marked 'type,' a two and a one. The one is the real type. Anterior slope steep. Interior bluish-white except the margin, which is narrowly and sharply coloured light brown with about 30 regular dark flecks; spatula well defined. No ribs outside; the shell is practically smooth. Outside it is a sort of mottled yellowish."

Notoacmea (Notoacmea) petterdi (Tenison-Woods). (Text-fig. E.)

Acmaea petterdi Tenison-Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 155, 1877 (north west coast of Tasmania: type in Tasmanian Museum): Pilsbry, *Man. Conch.*, vol. 13, p. 54, 1891. *Notoacmea petterdi* (Tenison-Woods): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 235, 1924. *Tectura septiformis* (not Q. & G.): Angas, *Proc. Zool. Soc.*, p. 220, 1867.

Specimens from Sydney have, through the kindness of Mr. Clive Lord, been compared with the type.

Description of specimens from Coogee, New South Wales: Shell broadly elliptical, moderately high, posterior slope arched, anterior also slightly convex, very steep. Apex in anterior fourth, sharp-pointed. Surface ornamented with about 28 fine radiating threads extending from apex to margin, interspaces several times broader than the ribs, smooth, with concentive growth-lines. Colour creamy white with about 40 light-brown radiating bands. Inside smooth, shining; the spatula brown, dark and light blotchy, ill-defined; surrounding the spatula it is bluish-white; margin broad, yellowish-brown banded with dark brown. Length, 24 mm.; breadth, 21·5 mm.; height, 9·5 mm.

In young shells the inside coloration, especially of exposed eroded specimens, is usually fairly dark, sometimes there being none of the bluish-white present; the outside also may be of a uniform brown colour except where erosion makes it a lighter shade. In half-grown shells there is often a good deal of brown inside with only a narrow band of bluish-white developed around the spatula. The bluish-white colour is always present in adult shells, and is accompanied by a thickening of the shell. The margin, however, always remains thin and sharp.

Radula of specimen from Port Jackson: Centrals with long bases, approximating towards the anterior end, and with long pointed brown cusps pointing directly outwards. Inner laterals small with triangular pointed brown cusps pointing towards outer edge of ribbon. Outer laterals short with broad brown obtuse cusps pointing towards centre.

Notoacmea petterdi bears a superficial resemblance to *N. pileopsis* of New Zealand, especially in its inside coloration. In shape and sculpture, however, it is quite different, and easily distinguished from every other Australian or New Zealand species.

Bionomics.—*Notoacmea petterdi* is abundant on rocks between tide-marks on the coast in the vicinity of Sydney. Small individuals occur in the barnacle association about half-tide, but the largest occur in the *Cellana* belt above this. These shells are often much eroded. Near high-tide mark in sheltered spots small well-preserved light-coloured shells occur with *Siphonaria* and *Tectarius*.

Distribution.—Tasmania: North-west coast. Victoria: Port Phillip, Mallacoota. New South Wales: Port Jackson, Newcastle. Queensland: Caloundra.

Subgenus PARVACMEA Iredale.

Parvacmea (subg. of *Notoacmea*) Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 428, 1915 (type: *Acmaea daedala* Suter).

Small shells, translucent, with usually a shelly deposit within. Apex forward, anterior slope concave, posterior convex. Closely related to the subgenus *Notoacmea*, differing mainly in size and in the texture of the shell.

Notoacmea (Parvacmea) daedala (Suter).

Acmaea flammea (not Q. & G.): Hutton, *Trans. N.Z. Inst.*, vol. 15. p. 132, 1883; *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 373, 1884. *Acmaea daedala* Suter, *Proc. Mal. Soc.*, vol. 7, p. 328, pl. 27, f. 30–32, 1907 (Auckland Harbour; type in Canterbury Museum); *Man. N.Z. Moll.*, p. 67, pl. 5, f. 11, 1913: Iredale, *Trans. N.Z. Inst.*, vol. 40, p. 379, 1908: Bucknill, *Sea-shells N.Z.*, p. 11, pl. 5, f. 9, 1924.

A small species with a thin shell which cannot be confused with any other species. It is allied to *N. septiformis*. The shell is elliptical, but the proportion of length to breadth varies, some shells being narrower than others. Posterior slope convex, anterior concave. Apex at about anterior fourth. There are microscopic radiating striae. Colour distinctive, being greenish-yellow with light-brown radiating and anastomosing lines. The depth of colour varies. The interior may be the same, or there may be a bluish-white callus except at margin, which is brown- and yellow-rayed. The callus increases in thickness with age. It begins as a ring between spatula and margin. The radula-teeth are quite similar to those of *Notoacmea pileopsis* and *N. septiformis*, the centrals being long with the cusps projecting and the inner laterals being larger than the outer.

Bionomics.—Plentiful along the coast under stones between tides, usually in sheltered situations, as rock-pools. It is gregarious.

Distribution.—Mangonui, Hauraki Gulf, Mount Maunganui, Gisborne, Cook Strait, Picton, Greymouth, Waipara, Banks Peninsula, Shag Point, Otago Peninsula.

Notoacmea (Parvacmea) subtilis (Suter).

Acmaea daedala Suter var. *subtilis* Suter, *Proc. Mal. Soc.*, vol. 7, p. 324, pl. 27, f. 33, 1907 (between Little Barrier Island and Tiritiri, in 20 fathoms; type in Wanganui Museum); *Man. N.Z. Moll.*, p. 68, pl. 5, f. 12, 1913.

Shell fragile and transparent, whitish with radiate narrow brown lines. This is apparently a deep-water form with the usual characteristics of a thin and light-coloured shell.

Distribution.—Hauraki Gulf, 10–20 fathoms (Suter); Awanui Bay, 12 fathoms.

Notoacmea (Parvacmea) nukumaruensis n. sp. (Plate 99, fig. 3.)

Description of type specimen (in Mr. H. J. Finlay's collection): Shell small, opaque, base elliptical, apex about anterior fourth, anterior slope straight, posterior slope falling away at first gradually then steeper towards margin. In region of apex the outer layer of shell is missing, elsewhere it is smooth except for concentric growth-lines. Shell white with about 25 radiating brown bands on lower portion. On posterior slope a few of these bands anastomose. Length, 4 mm.; breadth, 3 mm.; height, 2 mm.

Locality.—Nukumaru, north of Wanganui, in beds of Pliocene age. Besides the type specimen, two smaller shells were collected.

Notoacmea nukumaruensis is closely allied to *N. daedala* and *N. subtilis*. Possibly it is the species recorded from the Pliocene of Wanganui and Petane by Hutton under the name of *Acmaea flammea* (*Macleay Mem. Vol.*, p. 73, 1893).

Notoacmea (Parvacmea) helmsi (Smith). (Text-fig. F.)

Acmaea helmsi Smith, *Proc. Mal. Soc.*, vol. 1, p. 58, pl. 7, f. 4, 5, 1894 (Greymouth; type in British Museum): Suter, *Proc. Mal. Soc.*, vol. 7, p. 324, 1907; *Man. N.Z. Moll.*, p. 69, pl. 7, f. 3, 1913: Bucknill, *Sea-shells N.Z.*, p. 12, pl. 5, f. 8, 1924. *Notoacmea helmsi* (Smith): Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 428, 1915. *Acmaea parviconoidea* Suter var. *leucoma* Suter, *Proc. Mal. Soc.*, vol. 7, p. 322, 1907 (Heathcote Estuary; type in Wanganui Museum); *Man. N.Z. Moll.*, p. 70, 1913. *Acmaea scapha* Suter, *Proc. Mal. Soc.*, vol. 7, p. 324, pl. 27, f. 34, 35, 1907 (Dunedin; type in Wanganui Museum); *Man. N.Z. Moll.*, p. 72, pl. 5, f. 15, 1913. *Acmaea septiformis* (not Q. & G.): Suter, *Man. N.Z. Moll.*, p. 72, 1913 (in part; Suter's *septiformis* is a mixture of three species).

Notoacmea helmsi is a small species with a thin conical shell. Base broadly elliptical, almost orbicular, to narrow - oblong. Shell may be elevated or moderately depressed; apex subcentral or about anterior fourth. Upper surface dull, smooth. Margin sharp, interior shining. Outside of most ornamental specimens is greenish-brown with 30 to 40 radiating dark lines. Inside spatula is brown with a lighter centre; muscle-scar greenish with dark border; outside this is a broad greenish-white band; margin dark brown with light spots along edge. Lighter specimens are found. In some the outside is creamy white but inside is marked like the normal specimens, only paler; in others the outside is yellowish-white and the inside greenish-white surrounded by white with the margin yellow. On these light-coloured specimens was founded Suter's variety *leucoma*. They are, however, merely colour-variants of no taxonomic value. Very young specimens have the shell entirely brown. Apparently the colour-bands are not developed until the shell is 2–3 mm. in length.

The outline of base of shell is very variable. A shell from Heathcote Estuary is 10·8 × 9·8 mm. Two shells from Tauranga are 6·3 × 4·7 mm. and 5·6 × 3·3 mm. respectively. In this last specimen the sides are parallel. The type of *Acmaea scapha* is a young shell with parallel sides, and without the colour-rays developed. It differs only from the ordinary young ones in having the sides straight instead of curved.

Radula of specimen from Wellington Harbour: Centrals long with short recurved cusps, approximating towards the tips. Laterals in two pairs near the centre of the dental ribbon, short with small cusps.

Bionomics.—*Notoacmea helmsi* is found on stones, shells, *Zostera* leaves, and other objects on mud-flats between tide-marks in harbours and estuaries. Like all shells found in such situations, the apex and sometimes almost the whole of the outer surface are eroded. The narrow shells are probably epharmonic variations associated with life on stems of algae and leaves of *Zostera*. I have recorded *Notoacmea scapha* growing on *Zostera* leaves in Tauranga Harbour (*Trans. N.Z. Inst.*, vol. 44, p. 543, 1923). These shells were narrow but with sides not quite so straight as the type of *Acmaea scapha* with which they were compared. Narrow forms of *Acmaea* growing on *Zostera* and algae have been recorded for northern species: thus Pilsbry (*Man. Conch.*, vol. 13, 1891) mentions *A. depicta* and *A. triangularis*.

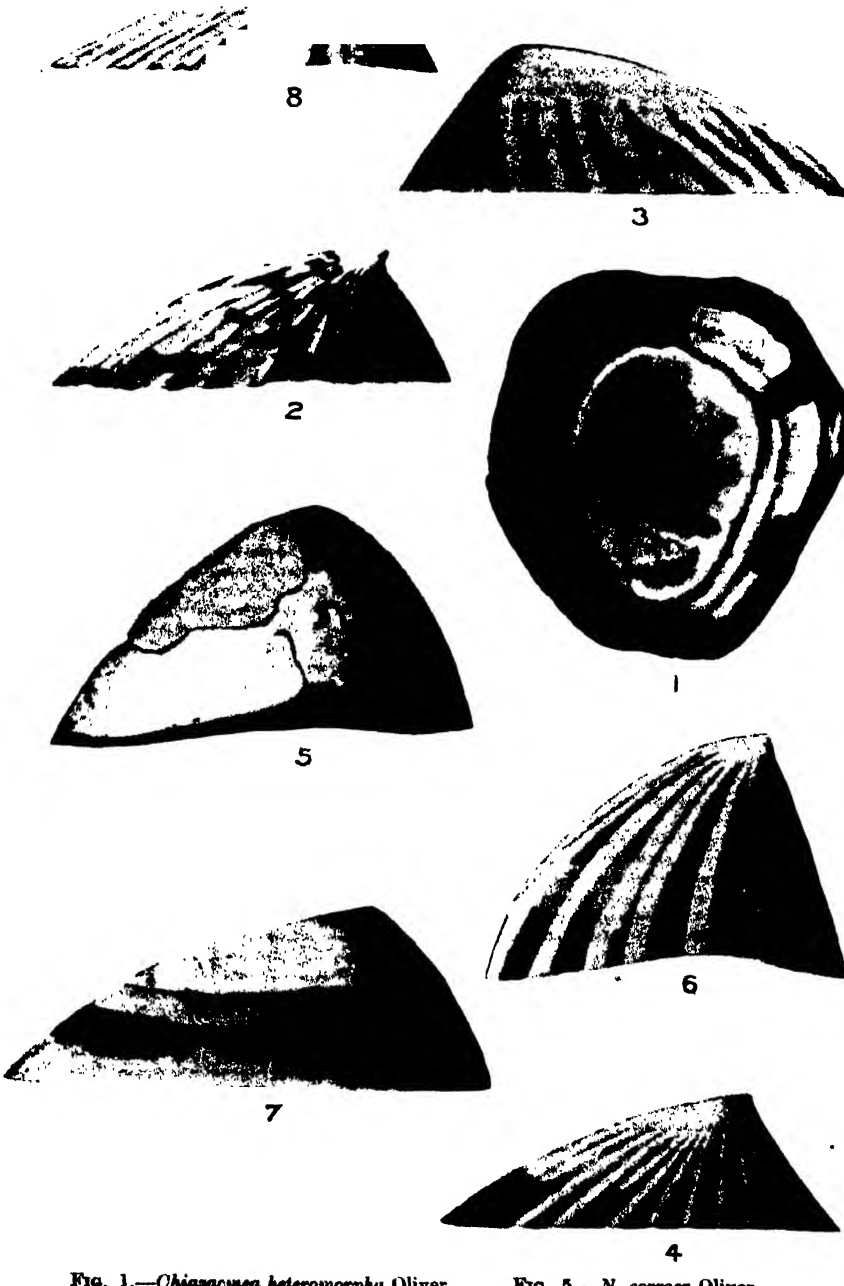


FIG. 1.—*Ohiaacmea heteromorpha* Oliver.
FIG. 2.—*Notoacmea pileopsis cellanoides* Oliver.
FIG. 3.—*N. nukumaruensis* Oliver.
FIG. 4.—*N. virescens* Oliver.
FIG. 5.—*N. corrosa* Oliver.
FIG. 6.—*N. alta* Oliver.
FIG. 7.—*N. badia* Oliver.
FIG. 8.—*N. scopulina* Oliver.

face p. 576.]

Distribution.—Doubtless Bay; Auckland, Tauranga, Wellington, Lyttelton, and Otago Harbours; Heathcote Estuary; Porirua Harbour, Blind Bay (Suter); Picton (Bucknill).

Notoacmea (Parvacmea) virescens n. sp. (Plate 99, fig. 4.)

Description of type specimen from Kekerangu (type in Dominion Museum): Shell depressed, apex anterior, anterior slope slightly concave, posterior slope slightly convex, smooth. Brownish-black with 32 radiating bluish-grey lines, several of them not reaching the margin. Interior greenish-white, the margin dark brown, banded along extreme edge with yellow rays. Anterior end of spatula pale green; an irregular brown blotch at apex (probably due to external erosion). Region outside muscle-scar slightly calloused. Length, 8·5 mm.; breadth, 7 mm.; height, 3 mm.

Range of variation: In young shells the colour-pattern of the apical region is best developed, and is then seen to consist of regularly anastomosing reddish-brown lines, radiate in the marginal region. The lighter rays are often distinctly greenish. In young shells all the light rays reach the margin, in adult shells many do not. The general colour darkens as the shell grows.

N. virescens is allied to *N. helmsi*, but differs in its smaller size, narrower outline, and narrower and more regular colour-bands reaching to the apex in young shells. It also approaches *N. daedala*, but is a larger, heavier shell, with different coloration.

Bionomics.—Living on intertidal rocks on the coast.

Distribution.—New Zealand: Kekerangu, on grey marls; Timaru.

Subgenus CONACMEA n. subg.

Small shells, conoidal or conical, generally elevated with all slopes more or less convex. No internal porcellaneous layer. Type: *Acmaea parviconoidea* Suter.

Notoacmea (Conacmea) parviconoidea (Suter).

Acmaea conoidea (not Q. & G.): Hutton, *Trans. N.Z. Inst.*, vol. 15, pp. 127, 132, pl. 15, f. K, 1883; *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 373, 1884. *Acmaea parviconoidea* Suter, *Proc. Mal. Soc.*, vol. 7, p. 321, pl. 27, f. 22–25, 1907 (Sumner; type in Canterbury Museum): Iredale, *Trans. N.Z. Inst.*, vol. 40, p. 378, 1908: Suter, *Man. N.Z. Moll.*, p. 69, pl. 5, f. 13, 1913: Bucknill, *Sea-shells N.Z.*, p. 12, pl. 5, f. 4, 1924. *Acmaea parviconoidea* Suter var. *nigrostella* Suter, *Proc. Mal. Soc.*, vol. 7, p. 322, pl. 27, f. 26–29, 1907 (Titahi Bay; type in Wanganui Museum); *Man. N.Z. Moll.*, p. 70, pl. 5, f. 14, 1913.

In reviewing the New Zealand Acmaeidae, Suter (*Proc. Mal. Soc.*, vol. 7, p. 322) pointed out that the New Zealand species was distinct from the Australian one described by Quoy and Gaimard as *Patelloida conoidea*, but at the same time he stated that he had specimens from Tasmania corresponding exactly with *A. parviconoidea*. The position was thus left in a confused state.

Notoacmea parviconoidea occurs in two rather distinct growth-stages. What I regard as the normal adult form of the species has apex about anterior third, anterior slope straight below but with apex advancing a little above, and posterior slope very slightly convex. It is generally a light-coloured shell with dark-brown radiating bands. In some shells these form a stellate pattern of fewer rays, often with a purplish tinge, in the apical portion of the shell. Young shells showing the coloured radiating

rays correspond with Suter's variety *nigrostella*, but are in my opinion merely colour variations of no taxonomic importance. *Nigrostella*, however, is the only name that has been applied to the ordinary form of the shell. The other growth-stage has both posterior and anterior slopes convex, posterior more so than anterior, and apex advances a little in front of curve of anterior slope. The colour of this form is usually a uniform black, or there may be a few light radiating bands. The type of Suter's *parviconoidea* belongs to this dark-coloured stage.

The relationship between these forms can be observed in good series from almost any locality. The dark (*parviconoidea*) is the young state. In certain situations, as on shells of *Mytilus*, it persists in this form throughout life, but on rocks it usually quickly changes to the light-coloured (*nigrostella*) form. Sometimes the change is very abrupt, and a dark convex form appears seated on a light straight-sided shell. Such shells are frequent on the piles of the pier at New Brighton, and it was through these that the relationship of the two forms was discovered.

Most of the shells included by Suter in his *nigrostella* are bleached specimens, white with traces of the stellate pattern remaining. In this state they look so distinct that they were not recognized as being the young of the ordinary rock form.

The radula has the centrals long with projecting pointed cusps. The inner laterals are shorter than the centrals but the cusps project in a similar way. The outer laterals are small.

Bionomics.—*Notoacmea parviconoidea* occurs abundantly throughout New Zealand in the intertidal belt, being especially common in the upper half. It is found in the most exposed situations and also within the shelter of harbours. On the shells of *Mytilus planulatus* and *Modiolus pulex* it occurs in the dark (*parviconoidea*) form. A proportion of the shells have light colour-bands, which, however, are generally absent on the posterior section of the shell. On rock-surfaces the shells are generally of the light-coloured, or *nigrostella*, type with the apical portion much eroded. In this state they are almost indistinguishable from shells of *Notoacmea scopulina*. The animals, however, are easily recognized, that of *scopulina* being yellow, while *parviconoidea* is nearly white.

Distribution.—New Zealand: from Maunganui Bluff and Doubtless Bay southwards to Greymouth and Otago Peninsula; Little Barrier Island, Great Barrier Island; Chatham Island (Suter).

Notoacmea (Conacmea) corrosa n. sp. (Plate 99, fig. 5, and text-fig. G.)

Acmaea conoidea (not Q. & G.): Tension-Woods, *Proc. Roy. Soc. Tas.*, 1877, p. 45, 1878: May, *Check-list Moll. Tas.*, p. 46, pl. 22, f. 4, 1921.

Description of type specimen: Shell conical, high, apex subcentral, anterior and posterior slopes convex, thin, margin sharp. With the exception of a narrow strip along margin the whole of exterior is eroded. Where not eroded surface is smooth but dull. Colour of eroded surface blotchy greyish and brown; of uneroded, brownish-black. Interior brownish, muscular impression lighter, margin jet-black. Contour of base elliptical, slightly narrowed in front, and with straight sides. Length, 8·5 mm.; breadth, 6·5 mm.; height, 5 mm. Type collected at Blackmans Bay, Derwent Estuary, Tasmania, and deposited in the Dominion Museum, Wellington.

Variations from type: There is little variation in the shape of the shell. Some are a little broader in proportion to length and some are more

elevated than others. Uncorroded apices are only to be found in very young specimens. The outside is sometimes marked by a few radiating light bands, usually a broad one at each outer posterior angle, and others may be present. The interior is usually darker than in the type; often it is entirely black except for the muscular impression, which is whitish. Light colour-bands on the outside show on the inside as yellowish bands at the margin.

Radula: Centrals approximate, long, with long pointed recurved cusps. Inner laterals as wide as the centrals and with long pointed cusps. Outer laterals small with pointed cusps.

Bionomics.—In the Derwent Estuary *Notoacmea corrosa* lives on rocks from about half-tide to high-tide mark. It is found in the *Mytilus planulatus* association and in the association of small-shelled animals above it. Like all shelled animals regularly exposed to the atmosphere, the exterior of the shell is more or less eroded. In adult specimens there is only a narrow margin of uneroded surface.

Distribution.—Tasmania.

Notoacmea (Conacmea) alta n. sp. (Plate 99, fig. 6.)

> *Acmaea conoidea* (not Q. & G.): Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 15, p. 195, 1903: Verco, *Trans. Roy. Soc. S. Aust.*, vol. 30, p. 214, 1906.

Description of type specimen from South Australia (in Dominion Museum): Shell conical, elevated, apex subcentral, acute, anterior slope nearly straight, posterior slope regularly arched. Margin sharp, plane of base arched. Shell smooth, with concentric growth-lines. Black with 18 pale-green bands radiating from apex; colour-bands show in interior. Length, 6 mm.; breadth, 5 mm.; height, 4 mm.

In radula centrals have long bases and long pointed projecting cusps, inner laterals have large blunt cusps and outer laterals are small.

Distribution.—South Australia: Port Macdonnell (Verco). Victoria: Barwon Heads, Port Phillip, Cape Otway (Pritchard and Gatliff).

The only specimen of this species that I have seen was sent by Mr. C. J. Gabriel, with the locality "South Australia." In its elevated form and radiate colour-bands it bears some resemblance to Quoy and Gaimard's *Patelloida conoidea*, hence I quote the above references and localities as referring to it. It recalls the juvenile form *N. parviconoidea* found on *Mytilus* shells.

Subgenus THALASSACMEA n. subg.

Shell thin, depressed, orbicular, apex central. Colour uniformly dark. Inner lateral teeth very broad. Type: *Notoacmea badia* Oliver.

Notoacmea (Thalassacmea) badia n. sp. (Plate 99, fig. 7; and text-fig. H.)

Description of type specimen: Collected at St. Clair, Dunedin, in rock-pool between tide-marks. Type in Dominion Museum, Wellington. Shell broadly elliptical, depressed, apex about anterior fourth, posterior slope convex, steep towards margin, anterior slope convex, steep. Apical portion eroded, lower portion slightly roughened. Eroded portion light-coloured, remainder purplish-brown, inside shining, dark brown, region of spatula lighter but varigated with darker markings corresponding with eroded areas outside. Length, 10·5 mm.; breadth, 9 mm.; height, 3·5 mm.

All the shells collected are uniform in shape and colour with the type. The species resembles *N. helmsi*, but is more depressed and bears no radiating colour-bands. The radula, however, is quite different. The centrals approximate at base, cusps blunt-pointed, inner edges straighter than outer, horn-colour with black edges. Inner laterals as broad as high, round at ends, distance between base about half width of base of a tooth, horn-colour with black margin. Outer laterals very small, blunt-pointed, horn-colour with blackish tip.

Bionomics.—Found only in rock-pools low down in the intertidal belt, where it is fairly common. The greater portion of the outside of the shell is eroded.

Distribution.—St Clair, Dunedin.

Subgenus SUBACMEA n. subg.

Shell conical, apex forward, regularly ribbed. Generally light-coloured with dark rays. Teeth nearly uniform in size with the inner laterals in advance of the outer. Type: *Notoacmea scopulina* Oliver.

Notoacmea (Subacmea) scopulina n. sp. (Plate 99, fig. 8; and text-fig. 1.)

Acmaea septiformis (not Q. & G.): Bucknill, *Sea-shells N.Z.*, p. 13, pl. 5, f. 3, 1924.

Description of type specimen: Shell somewhat depressed, apex at anterior third, posterior and anterior slopes convex. Base ovoid-elliptical, sides tapering towards anterior end which is narrower. About 30 low radiating ribs. Colour of ribs white, interspaces black. Interior smooth and shining, bluish-white faintly rayed with dark lines corresponding to interspaces between ribs. A few dark-brown blotches near apex corresponding with eroded portions on outside. Margin striped with dark brown and white. Length, 15 mm.; breadth, 12 mm.; height, 4·5 mm. Type from Motutara, west coast of Auckland (in the Dominion Museum).

Variations from type (Motutara specimens): Shape of shell fairly constant. Smaller shells narrow-elliptical, larger ones regularly elliptical (that is, not narrowing much in front). A few specimens are moderately elevated. In the larger specimens ribs increase by interpolation to about 40. There is considerable variation in the coloration of the interior. A bluish-white tinge is evident in most specimens. Dark-brown blotches are few or many according to the amount of erosion on outside. There is usually a dark-brown or blackish band within margin, which always shows alternate black and white rays. A characteristic feature are white radiating rays on darker bluish background. Largest specimen—length, 19 mm.; breadth, 15 mm.; height, 5 mm.

Specimens similar to those from Motutara come from Charleston, on the west coast of the South Island.

I have associated with the Motutara specimens in the present species a form common on intertidal rocks at Lyall Bay and St. Clair. They have about 25 ribs showing only at margin, the remainder of surface being eroded. Interior bluish or brownish white with dark blotches corresponding to eroded areas on outside. There is a submarginal dark band, outside which are the alternating black and white rays of margin. Length, 10–12 mm. These specimens present an appearance somewhat different from the majority of the Motutara specimens, but this is apparently due to the difference of habitat, and to the fact that the Motutara specimens are for the most part covered with *Melobesia*. Clean eroded specimens from both localities closely resemble one another, and appear to me to be conspecific.

The radula of the Motutara specimens has two broad short centrals approximating in the middle line and with broad recurved cusps. The laterals, of which there are two pairs, the posterior slightly more divergent than the anterior, which are separated by a distance equal to about half the width of the cusps, have broad cusps. All the teeth are thus of approximately the same size.

Bionomics. Mr. A. W. B. Powell, who collected the Motutara specimens, describes the habitat as "on perpendicular rock, high up but exposed to the fullest force of the waves at high water." Most of the shells are covered with *Melobesia*, which protects them from erosion. When clean they are deeply eroded over the upper half.

At Lyall Bay *Notoacmea scopulina* is found associated with *N. parviconoidea* on rocks in the *Porphyra* and *Chamaesipho* associations in the mid-tide belt. They are clean, but deeply eroded except near margin.

Distribution.—New Zealand: Motutara, Charleston, Lyall Bay, St. Clair.

Bucknill records *A. septiformis* from Chicken Island, Dunedin, Auckland and Campbell Islands.

Notoacmea corrodenda (May).

> *Patelloida corrodenda* May, *Proc. Roy. Soc. Tas.*, 1919, p. 66, pl. 17, f. 24, 1920 (Frederic Henry Bay, Tasmania).

Notoacmea corrodenda is distinguished by its rather depressed form, with apex in anterior third, and the numerous (20 to 40) low radiating ribs. Apex usually eroded. Ribs white, and interspaces between them at margin black. In interior spatula is brown with white border. Outside the muscle-impression is a light- or dark-brown band, margin banded black and white, the white corresponding to ribs. Radula has centrals with long bases and long projecting sharp-pointed cusps. The inner laterals have short bases and projecting pointed cusps shorter than the centrals. The outer laterals are small. The radula is thus essentially similar to that of *Notoacmea pileopsis*.

Notoacmea corrodenda is closely related to the New Zealand species *N. scopulina*, differing principally in coloration, the white margined spatula being especially characteristic of *corrodenda*.

Bionomics.—*Notoacmea corrodenda* is common in the Derwent Estuary, living with *N. corrosa* and *Chiazacmea flammea* on intertidal rocks. It is found in the *Mytilus planulatus* association and the open rock-association above it. The exterior is generally eroded over more than half the surface. May records this species on rocks about half-tide mark, associated with *Siphonaria diemenensis*.

Distribution.—South-east Tasmania.

ATALACMEA Iredale.

Atalacmea Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 427, 1915. Type: *Patella fragilis* Sowerby.

This genus includes but a single species, and is an extreme form, apparently developed in response to the particular conditions under which it lives. The shell is much depressed, being nearly flat, broadly elliptical, truncate in front, apex near anterior margin and directed forwards.

The radula-teeth resemble those of *Notoacmea pileopsis*. The centrals are long with long projecting sharp-pointed cusps. The inner laterals

have shorter bases but similar long sharp-pointed projecting cusps. Outer laterals small.

Atalacmea is apparently an offshoot of *Notoacmea*, and is distinguished by its extraordinary shell.

Atalacmea fragilis (Sowerby).

Patella fragilis Chemnitz,* *Conch. Cab.*, vol. 11, f. 1921, 1290: Sowerby, *Genera Shells, Patella*, pl. 140, f. 6, 1823. *Patella unguis-almae* Lesson, *Voy.* "*Coquille*," *Zool.*, vol. 2, p. 420, 1830. *Acmaea unguis almae* (Lesson): Odhner, *Vid. Medd. Dansk. Nat. For.*, Bd. 77, p. 10, 1924. *Patella solandri* Colenso, *Tas. Jour. Sci.*, vol. 2, p. 226, 1844 (Tokomaru); *Trans. N.Z. Inst.*, vol. 14, p. 168, 1882. *Patelloida fragilis* (Chemnitz): Q. & G., *Voy.* "*Astrolabe*," *Zool.*, vol. 3, p. 351, pl. 71, f. 28–30, 1834: Desh. & Edw., *Lam. Anim. s. Vert.*, ed. 2, vol. 7, p. 552, 1836. *Tectura fragilis* (Chemnitz): Hutton, *Cat. Mar. Moll. N.Z.*, p. 43, 1873: von Martens, *Crit. List Moll. N.Z.*, p. 35, 1873. *Acmaea fragilis* (Chemnitz): Hutton, *Man. N.Z. Moll.*, p. 88, 1880; *Proc. Linn. Soc. N.S.W.*, vol. 9, p. 374, 1884: Pilsbry, *Man. Conch.*, vol. 13, p. 59, pl. 37, f. 14, 15, 1891: Suter, *Proc. Mal. Soc.*, vol. 7, p. 317, pl. 27, f. 11 (dentition), 1907; *Man. N.Z. Moll.*, p. 68, p. 7, f. 2, 1913: Bucknill *Sea-shells N.Z.*, p. 12, pl. 5, f. 5, 1924. *Atalacmea fragilis* (Sowerby): Iredale, *Proc. Linn. Soc. N.S.W.*, vol. 49, p. 238, 1924.

In the extremely depressed almost flat form this species is quite unlike any other. I have found no variation in the species. Outside, shell is whitish concentrically banded with light brown; inside there is a broad concentric green band and a green patch down centre, but the shell being translucent the green is visible from above and dominates colour of exterior.

Bionomics.—This species occurs under stones between tide-marks, usually nearer low-tide mark. It almost invariably affects smooth stones, and when disturbed moves off at a fair speed. It is a gregarious species. The shells are always clean.

Distribution.—Tom Bowling Bay, Little Barrier Island, Taranga Island, Whangarei Heads, Hauraki Gulf, Slipper Island, Tauranga, Maria Peninsula, Cook Strait, Banks Peninsula, Shag Point, Tokomaru (Colenso), Chatham Islands (Suter), Stewart Island.

ACKNOWLEDGMENTS.

It would have been impossible to write the foregoing account without the assistance of many who have willingly and often at much trouble gathered for me the specimens I required. I have also received specimens, including types, on loan, and have obtained information from persons to whom types were accessible. Therefore, for much help freely given, I wish to express my sincere thanks to the following: Messrs. E. Ashby, Blackwood, South Australia; C. Barrett, Melbourne; A. E. Brookes, Matamata; H. J. Finlay, Dunedin; C. J. Gabriel, Melbourne; H. Hamilton, Wellington; Dr. E. Lamy, Paris; Messrs. C. Lord, Hobart; W. L. May, Sandford, Tasmania; Miss M. K. Mestayer, Wellington; Messrs. H. S. Mort, Sydney; A. W. B. Powell, Auckland; Professor R. Speight, Christchurch; Dr. J. Allan Thomson, Wellington; Mr. J. R. le B. Tomlin, St. Leonards-on-Sea, England; Mr. C. Walton, Adelaide. I also desire to thank Miss E. Richardson for assistance in preparing the illustrations.

* This name is rejected because Chemnitz was not a binomialist, though binomials are the rule in the volume in which it was described.

New Zealand Mollusca: No. 3.

By MARJORIE K. MESTAYER, Dominion Museum.

[*Read before the Wellington Philosophical Society, 22nd October, 1924; received by Editor, 31st December, 1924; issued separately, 5th May, 1926.*]

Plates 100, 101.

THE specimens dealt with are in the Dominion Museum collection. Two of them, *Plaxiphora zigzag* (Hutton) and *Plaxiphora ovata* (Hutton), though described in 1872, had never been adequately figured. Another old specimen is *Callochiton kapitiensis* n. sp., which had been identified by Hutton as *Chiton sulcatus* Quoy, and by Suter as *Chiton limans* Sykes; but Mr. Edwin Ashby, to whom the broken paratype was sent, said it was an undescribed *Callochiton*. I gratefully acknowledge Mr. Ashby's kindness and help in identifying this and other species. Thanks are also due to Mr. W. R. B. Oliver for generous help and for his notes on the radulae of *Callochiton empleurus* (Hutton), *Macandrellus oliveri* n. sp., and *Lorica haurakiensis* Mestayer. Though I include figures of the radulae of these and of *Acanthochiton foveauxensis* and the var. *kirki*, I have not attempted to describe them; the slides, however, are in the Dominion Museum. I am much indebted to Miss J. K. Allan for the care she has bestowed on the drawings.

Callochiton empleurus (Hutton). (Plate 100, fig. 1.)

The radula of this species has, I believe, never been figured. I am indebted to Mr. W. R. B. Oliver for this note: "Median tooth narrowing distally, outer centrals with broad cusps. Laterals with a large black cusp ending in three strong points, the central one rounded, the outer ones sharp, pointed. Nine marginals with long cusps pointing inwards, outer pavement-like, the outer row the largest."

Callochiton kapitiensis n. sp. (Plate 100, figs. 2–4.)

Chiton sulcatus Quoy, *Trans. N.Z. Inst.*, vol. 4, p. 178, 1872. *Chiton limans* Sykes: Suter, *Proc. Malac. Soc.*, vol. 2, p. 197.

Shell small, narrow-oval, side slopes very slightly convex, jugum acute, mucro median,

Colour.—Shell whitish-brown, mantle reddish-brown.

Sculpture.—The head-valve, lateral areas, jugal area, and posterior two-thirds of tail-valve closely covered with very minute granules, clearly defined only under a strong hand-lens. Two concentric growth-lines clearly marked on all valves. Posterior margins of valves 1–7 finely denticulate. Under lens two other growth-lines can be seen on head-valve. Median valves—lateral areas strongly marked, pleural areas with 8 very narrow raised longitudinal ridges, interstices about three or four times width of ridges. Posterior margins straight. Valves 6 and 7 of holotype badly broken on right side. Tail-valve—pleural areas ridged, mucro small, nearly central, posterior portion slightly concave. Girdle narrow, densely covered with small pillar-like scales (Plate 100, fig. 4), in mottlings of reddish-brown and white.

Length, 9 mm.; breadth, 5 mm.

Locality.—Kapiti Island, Cook Strait.

Holotype and one perfect and one imperfect paratype in Dominion Museum.

Remarks.—The disarticulate remains of a paratype show that the insertion plates are narrow, head-valve with 15 or 16 very shallow slits, median valves 1 slit, and the interior bluish-white. A single imperfect valve in my collection, from Lyall Bay, is pink and white exteriorly, with the interior jugal area rosy pink

Suter's (5) inclusion of *Chiton limans* Sykes in the New Zealand fauna appears to have been based on the specimens in the Dominion Museum; but his description does not at all fit these specimens from Kapiti Island, it being apparently Carpenter's MS. description—Pilsbry (7). In the *Proc. Malac. Soc.* (6), *Chiton limans* is used by Sykes for a Port Phillip shell so named in MS. by Carpenter. This being so, and the New Zealand shell being radically different from *C. limans* Sykes, an Australian shell, I would suggest that *C. limans* Sykes should be struck out of the New Zealand fauna.

The following note by Mr. Edwin Ashby is on the paratype, since disarticulated:—

"The specimen is in a much-damaged condition, half of the first four valves being missing. An examination under a hand-lens at once showed that it was a member of the genus *Callochiton*, for the girdle is clothed with the needle-like or rod-like scales so characteristic of that genus. The strong longitudinal ribbing of the pleural areas of the median valves places it as a near relative to the rare Australian *Callochiton mayi* Torr. Girdle—The girdle needles are much coarser than those of *mayi*, although very similar in character. The shell is slightly more carinated than *mayi*, though the side slope is slightly rounded in both. The longitudinal ribbing in *mayi* is flatter on the upper side, reminding one of weatherboarding, whereas in the specimen under examination the longitudinal ribs are true ribs, equally raised on either side, and are also subgranulose, very similar to the ribbing of *Lorica cimolea*. The lateral areas in this specimen from Kapiti are strongly raised and strongly toothed on the posterior margin, the area is convex, finely granulose with strong concentric growth-ridges; whereas in *mayi* the lateral area is almost smooth, both the anterior and posterior margins raised, not toothed, slightly granulose only, making this area longitudinally concave, some growth-sulci are present. The anterior valve in *mayi* is minutely subgranulose, whereas in the species under review it is markedly granulose with toothed margin."

Since writing the above a living specimen of *Callochiton kapitiensis* was obtained (in February, 1925), adhering to the under-surface of an *Astraea heliotropium* (Martyn), which had got caught on a fishing-line near Kapiti Island. It is slightly smaller than the holotype, which is an old specimen; the present specimen was measured before being dried.

Colour.—Shell light brown, the lower two-thirds of lateral areas of valves 3–5 dark brown; tail-valve dark brown with a white stripe from mucro to margin. Girdle same colout as shell, faintly mottled with dark brown, with fine hair-like spicules scattered about it, and a very delicate fringe at the edge.

Plaxiphora zigzag (Hutton). (Plate 100, figs. 5–6.)

Tonicia zig-zag Hutton, 1872.

As this and the following species have not hitherto been adequately figured, I give drawings of the holotype. Hutton's description appears in *Trans. N.Z. Inst.*, vol. 4, p. 180, 1872.

For many years this species was merged with *Plaxiphora caelata* (Reeve), but Iredale (2) has recognized it as a distinct species.

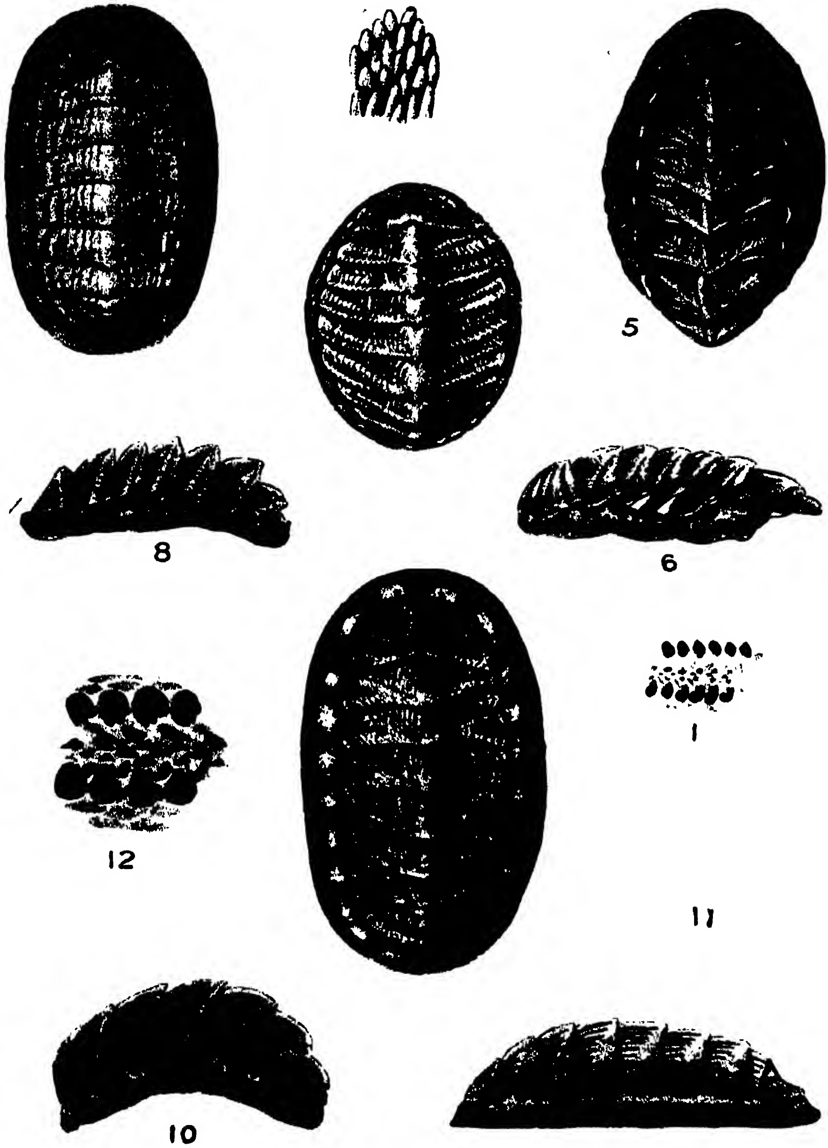


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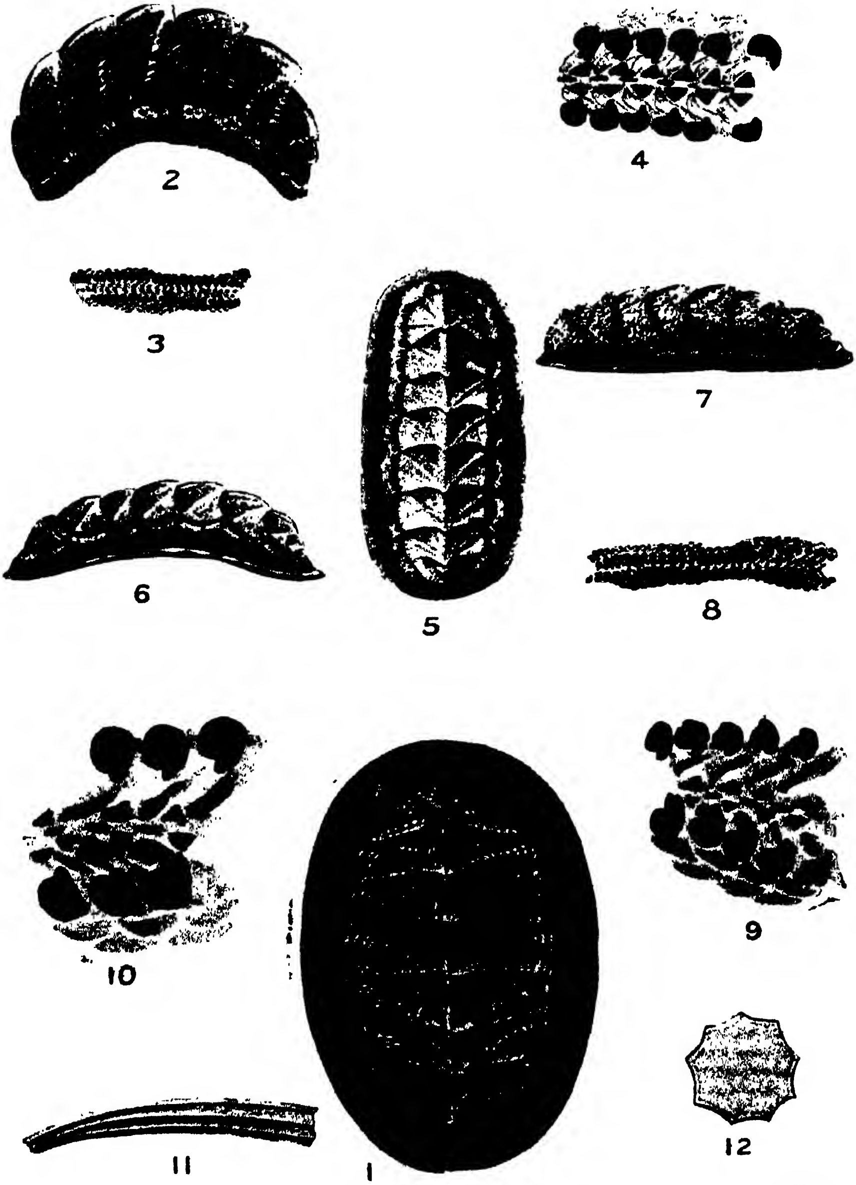
FIG. 1.—*Callochiton empleurus* (Hutton): radula.
FIG. 2.—*Callochiton kapitiensis* n. sp.: holotype.
FIG. 3.—*Callochiton kapitiensis* n. sp.: lateral view.
FIG. 4.—*Callochiton kapitiensis* n sp.: girdle-scales.
FIG. 5.—*Plaxiphora zigzag* (Hutton): holotype.
FIG. 6.—*Plaxiphora zigzag* (Hutton): lateral view.
FIG. 7.—*Plaxiphora ovata* (Hutton): holotype.
FIG. 8.—*Plaxiphora ovata* (Hutton): lateral view.
FIG. 9.—*Acanthochiton foveauxensis* n. sp.: holotype.
FIG. 10.—*Acanthochiton foveauxensis* n. sp.: lateral view.
FIGS. 11, 12.—*Acanthochiton foveauxensis* n. sp.: radula.

Face p. 584.]



[J. K. Allan, del.

FIG. 1.—*Acanthochiton foveauxensis kirki* n. var. holotype.
FIG. 2.—*Acanthochiton foveauxensis kirki* n. var. . lateral view.
FIG. 3.—*Acanthochiton foveauxensis kirki* n. var. : radula.
FIG. 4.—*Acanthochiton foveauxensis kirki* n. var. : radula.
FIG. 5.—*Macandrellus oliveri* n. sp. : holotype.
FIG. 6.—*Macandrellus oliveri* n. sp. holotype, lateral view.
FIG. 7.—*Macandrellus oliveri* n. sp. paratype, lateral view.
FIG. 8.—*Macandrellus oliveri* n. sp. . holotype, radula.
FIG. 9.—*Macandrellus oliveri* n. sp. : holotype, radula.
FIG. 10.—*Lorica haurakiensis* Mestayer : radula.
FIG. 11.—*Dentalium marwicki* n. sp. : holotype.
FIG. 12.—*Dentalium marwicki* n. sp. : holotype, transverse section.

Plaxiphora ovata (Hutton). (Plate 100, figs. 7, 8.)

Acanthochaetes ovatus Hutton, 1872.

Hutton's description appears in *Trans. N.Z. Inst.*, vol. 4, p. 182, 1872. Suter, in *Man. N.Z. Moll.*, 1913, pp. 1079–80, places it as a synonym of *P. egregia* A. Adams, 1866, on Iredale's authority (4); but in 1917 I sent several specimens to Mr. Suter, and he confirmed my doubts as to its specific identity, as his note following clearly states:—

"Before opening your box I looked over my spirit specimens, and there I found one specimen of *P. egregia* I once, long ago, collected at New Brighton. Most certainly it is distinct from *P. ovata*. My specimen is larger than yours. The sculpture of the valves is almost exactly alike, but the lateral-pleural areas I found to have 25–26 longitudinal riblets on each area, against about 20 in *P. ovata*. The chief differences are in the outline of the shell, ratio of width to length, also that of the fourth or fifth intermediate should be stated. If you disarticulate a specimen of each you may find differences in the sinus, the sutural laminae, position of slits, &c. The radulae also may show differences."

Moreover, A. Adams notes "unknown habitat," though there are other specimens conspecific with it in the British Museum.

I believe that *P. egregia* A. Adams is the commoner species in New Zealand, but at present am decidedly of opinion that *P. ovata* (Hutton) should be recognized as at least a readily separable variety, if not as a distinct species.

Acanthochiton foveauxensis n. sp. (Plate 100, figs. 9–12.)

A. rubiginosus (Hutton), 1872; *Man. N.Z. Moll.*, 1913, p. 29.

Shell oblong, small, surface granular, side slopes straight.

Anterior valve—5 indistinct radiate ribs, the granules on central rib larger than the others. Median valves—the centre of jugum smooth, with a narrow, triangular, longitudinally striate portion on either side. Lateral areas slightly raised, pleural and lateral areas closely covered with variable-sized granules. Valves subcarinate, beaked. Posterior valve small, mucro central, posterior slope lightly concave; granules mostly smaller than on median valves. Mantle fleshy, 4 mm. in width before drying, with a dense covering of very fine spicules giving a silvery or golden sheen in some lights. On either side are 7 sutural tufts of slightly larger bristles, and 4 in front of the head-valve. These bristles are very friable and it is rare to find a perfect tuft; there is also a fringe of very fine spicules round the edge of the mantle, but the slightest friction destroys it.

Colour very variable; in holotype, jugum reddish with triangular white stripe on either side, shading to deep purple at edges. While wet the mantle was yellowish, rather darker round head-valve, irregularly blotched with purplish-brown, sutural tufts nearly surrounded by whitish patch.

Variations.—There is considerable variation in coloration in both shells and girdles, before drying. The girdles mostly yellowish-brown with white spots round sutural tufts, and purplish blotches. On the valves the colour is extremely variable. While a purplish-pink is the predominant tone, the edges of some specimens are dark purple, with many of the granules green, and in a number of specimens the jugum of the second valve is bright orange. Occasionally a bright blue-green one is found.

The jugal area of many specimens differs from the typical form in being finely granular rather than striate, the granules more crowded, and lateral areas less clearly defined.

Interior white, with a large rose-pink patch in centre of valves 1–7, tail-valve only showing a slight trace of colour.

Insertion plates well developed, lateral valves with 1 slit, head-valve 4 slits; in tail-valve the number of slits very variable, mostly 4–7; but of a considerable number of specimens examined one had only 3, and another 13; the teeth nearly vertical. Insertion plate narrow and marked between the slits by shallow grooves; the teeth on the head-valve are also grooved. Valve-callus well developed. Sinus well marked, lightly convex.

Length, 15 mm.; width, 13 mm.; but the holotype is much contracted, and by no means the largest specimen.

Locality.—Foveaux Strait, on the oyster-beds.

Holotype in Dominion Museum.

Acanthochiton foveauxensis var. kirki n. var. (Plate 101, figs. 1–4.)

In most particulars the foregoing description of the species applies equally to this variety, which seems to be sufficiently separable as a variety, and it gives me much pleasure to associate Professor H. B. Kirk's name with this particularly pretty form, in grateful recognition of his unfailing kindness.

Differences.—The most easily seen difference is the more regular diagonal arrangement of the granules, clearly shown in Plate 101, fig. 1; also, these granules are rather square and flatter than in the species, less crowded, especially on the pleural areas, and slightly smaller. Another frequent difference is coloration; but this is not a constant feature, many having the colour of *A. foveauxensis*; a considerable number have some or all the valves a deep old rose, and some show traces of light brown. The orange patch on the jugum also occurs.

This variety is separated on the sculptural difference, which is found in very young as well as adult specimens.

Length (holotype in Dominion Museum), 12 mm.; width, 11 mm. A contracted specimen, of average size.

Macandrellus oliveri n. sp. (Plate 101, figs. 5–9.)

Shell narrow-oval, high-arched, suface dull, closely covered with small scale-like granules.

Anterior valve with 5 low very indistinct radiating ribs, slightly beaked, granules on ribs very slightly larger than elsewhere. Median valves—jugum smooth between the numerous minute pits. Lateral areas raised. Valves beaked. Posterior valve small, mucro median, rather prominent, posterior portion sharply concave. Mantle broad, probably fleshy, 7 sutural pores on each side, 4 in front of head-valve, which in life evidently had tufts of rather long bristles, also probably fine spicules all over the mantle. Interior insertion plates (from a paratype) broad, rounded, but dropping steeply down to the nearly straight sinus. Head-valve with 5 slits, teeth about one-third total height of valve. Median valves 1 slit. Tail-valve 9 slits, of which the first and ninth are the most decided.

Colour inside of valves a dirty greenish-white, but another specimen pinkish-white. Externally the shell is a dull brown, slightly darker along the ridge.

Length of holotype, 27 mm.; width, 14 mm. (a dried specimen).

Localities.—Coromandel Peninsula, Hauraki Gulf, 20 fathoms (type); Cape Kidnappers, Hawke's Bay, 15–25 fathoms.

Named in honour of Mr. W. R. B. Oliver, who presented the holotype and some paratypes to the Dominion Museum.

As shown in Plate 101, figs. 6, 7, there is some variation in the size of the granules.

The size of the teeth on the head-valve and the character of the insertion plates of the median valve, with the overhanging mucro on the tail-valve, have led me to place this species in *Macandrellus*, rather than in *Acanthochiton*, where it was first placed.

Its nearest ally is *Macandrellus mariae* (Webster), which it closely resembles in sculpture and in the very peculiar tail-valve.

For the accompanying note on the radula (Plate 101, figs. 8, 9) I am indebted to Mr. Oliver: "Median tooth narrow, outer centrals with a broad cutting-edge. Laterals large, with long bases and a broad black cusp with two long sharp pointed cutting-points. Inner marginals with dark-brown pointed cusps, the third much longer than the others; outer marginals trapezoid."

Radula of **Lorica haurakiensis** Mestayer. (Plate 101, fig. 10.)

Centrals expanded distally into wide curved cusps. Lateral with a large black cusp terminated by a single strong sharp point. Third marginal with a long pointed cusp; outer marginals oblong, increasing in size outwards.

Dentalium marwicki n. sp. (Plate 101, figs. 11, 12.)

Shell small, lightly curved, tapering.

Sculpture.—9 strong rounded ribs, which tend to become obsolete in old specimens. Anterior aperture thin, slightly oblique, the ribs only faintly marked internally. Posterior orifice small, with a very thick wall.

Length, 20 mm.; breadth, 2·5 mm.

Localities.—Castlecliff (lower bed), Pliocene (type). Recent specimens are found in dredgings from Manukau Harbour; off Oamaru, 50 fathoms; Otago Heads, 60 fathoms (H. J. Finlay); Hen and Chickens Islands, 25–33 fathoms; Great Barrier Island, 110 fathoms (9). In this last record *Dentalium nanum* Hutton is recorded by Murdoch and Suter, but I have broken fragments of both species taken from a little sample of that particular dredging.

Holotype in Dominion Museum.

Remarks.—In old specimens the aperture becomes almost circular. The number of ribs varies from 8 to 10 in individual specimens, the last number being apparently exceptional.

This species is nearly allied to *D. nanum* Hutton, from which it is distinguished by its fewer and more rounded ribs.

Named in honour of Dr. J. Marwick, of the Geological Survey, who was the first to recognize it as a new species, and in grateful acknowledgment of his unfailing kindness and help.

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5. *N.Z. Moll.*, 1913, p. 39.
6. *Proc. Malac. Soc.*, vol. 2, 1903, p. 93.
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New Species of Recent Mollusca.

By Albert E. Brookes.

[*Read before the Auckland Institute, 25th November, 1924; received by Editor, 28th November, 1924; issued separately, 5th May, 1926.*]

Plate 102.

Vexillum Bolten, 1798, *Mus. Bolten.*, vol. 2, p. 138.

Vexillum antipodum n. sp. (Plate 102, fig. 1.)

Shell small, fusiform, rather solid and axially costate, ochreous, banded with purple-black. Sculpture: all whorls except protoconch distinctly axially costate between sutures. Costae somewhat broadly rounded, beginning on the lower edge of whorl-shoulders and hardly reaching the sutures; there are also several moderately distant spiral lirae present on each whorl, in some cases extending over costae, stronger on lower half of body-whorl, where the ribs gradually become obsolete; shoulders below sutures with 2 or 3 fine spiral cords, the whole shell finely sculptured with axial growth-lines; neck of columella with 5–6 oblique fine ribs, the two upper separated from the others by a rather broad rounded groove. Protoconch smooth, of 1½ turns. Whorls 7, slightly angulated, with impressed sutures, outlines slightly convex, apex rounded, a little flattened above. Spire elevated, conical, very little higher than aperture. Aperture moderately narrow, oblique, nearly half height of shell, slightly angled above, with a short open almost straight canal somewhat crenulated on base owing to spiral ribs on neck of columella. Outer lip moderately rounded, solid, margin sharp. Columella subvertical, with 4 plaits, the two lower oblique, closer together than upper ones, which are more widely separated, and the top one nearly transverse; a narrow groove divides plaits from neck-spirals. Colour: ground-colour ochreous-buff, with a broad purple-black band on the lower half of body-whorl, also a very narrow band of same shade immediately above suture of penultimate whorl and two preceding it; the upper whorls of a lighter shade without sutural bands; protoconch flesh-coloured, base of columella orange.

Diameter, 4·2 mm.; height, 10 mm. Angle of spire, 70°.

Animal unknown.

Holotype and two paratypes in author's collection.

Habitat.—Cooper's Beach, Doubtless Bay (A. E. B.): type. Also obtained by Mr. W. La Roche, of Auckland, in the same locality.

Situation: Under loose boulders embedded in sand between tide-marks.

This species is the finest yet discovered in New Zealand, and is apparently restricted to very narrow limits, and not at all common. It appears to be more closely allied to *V. planatum* Hutton than to any other New Zealand species, but is at once distinguished by the conspicuous colour-bands.

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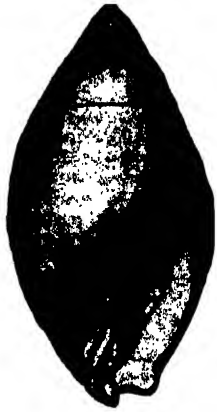

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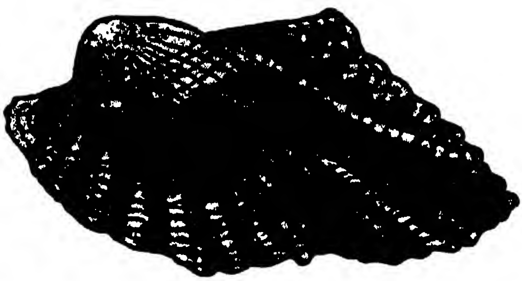

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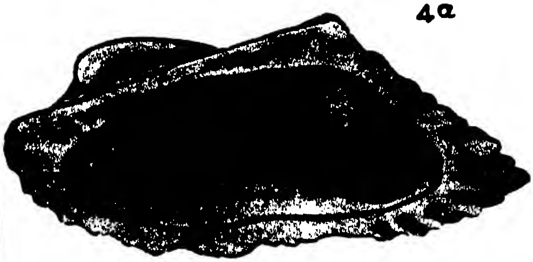


4a

FIG. 1.—*Vexillum antipodum* n. sp.; 4·2 × 10 mm.
FIG. 2.—*Ancilla crystallina* n. sp.; 5·1 × 11·6 mm.
2a. Operculum, highly magnified.
FIG. 3.—*Laevilitorina iredalei* n. sp.; 1·5 × 2 mm.
FIG. 4.—*Arca sociella* n. sp.; 5 × 2·2 mm.
4a. Interior.

Face p. 588.]

ANCILLA Lamarck, 1799, *Mem. Soc. Hist. Paris*, p. 70.

Ancilla crystallina n. sp. (Plate 102, figs. 2, 2*a*.)

Shell small, ovate-elongate, semitransparent, white. Spire conical, short, less than height of aperture, apex mucronately rounded, outlines nearly straight. Whorls apparently 6, evenly covered with enamel except portion of protoconch which consists of 1½ turns, body-whorl gradually narrowly rounded towards base, of moderate size, outlines convex. Sculpture: spire very finely granulated, this feature extending to callus of upper portion of inner lip; lower half of body-whorl with very fine distinct growth-lines crossed by equally fine spiral lirae, giving this portion of shell a finely decussated appearance under an ordinary lens; on upper portion of base there are two narrow grooves not widely separated, and another lower down. Sutures superficial, covered with enamel. Aperture oblique, high, rounded, angled and canaliculate above and below, convex on lower, concave on upper inner side. Base truncate and deeply notched. Outer lip subvertical, only slightly curved, thin and sharp; base rounded, with two minute projections at junction of upper basal groove. Inner lip not broadly calloused below but widening out on upper portion and extending well on to spire. Base of columella a little recurved, with a broad open canal, neck obliquely plicated, with a solid callus pad at extremity. Fasciole broad and flat, separated from inner lip by a groove, shallow at the extremities but deepening in middle. Colour crystalline white with apex of spire light orange-chrome, sutures with narrow bands of almost pure white. In the type the dorsal portion of shell appears to be stained with iron oxide, but the paratypes do not show any trace of colour except at apex. Operculum thin, horny, transparent, tinged with yellow in centre, elongate, nucleus subapical, faintly sculptured with fine subcircular growth-lines, with a few prominent ones more distantly placed. There are also two distinct ridges beginning towards apex, inner one short, outer one a little lower, and continuing parallel with the outer margin round base; there is also a subcentral area somewhat thickened, with irregular markings.

Diameter, 5·1 mm.; height, 11·6 mm. (type—large specimen): 4·4 × 9·9 mm., 4 × 8·9 mm. (paratypes). Angle of spire, 64°.

Animal unknown.

Holotype and several paratypes in author's collection.

Habitat.—Russell, Bay of Islands (A. E. B.).

Situation: Dredged in 3–5 fathoms, bottom of fat mud.

Three specimens were obtained alive and three dead; the dead specimens are chalky, without the coloured apex. In general outline this species resembles *A. mucronata* Sow.

LAEVILITORINA Pfeffer, 1886, *Jahr. Anst. Hamburg*, vol. 3, p. 81.

Laevilitorina iredalei n. sp. (Plate 102, fig. 3.)

Shell small, elongate, obliquely conical, light-horn-coloured, shining beneath the coating of dirty brown. Epidermis thin, dull, easily removed. Sculpture consists of microscopic growth-lines only. Whorls 4½, rather rapidly increasing, the last larger than all the others taken together, outlines convex. Sutures impressed, margined. Protoconch of about 1¼ turns, roundly flattened. Spire a little higher than aperture. Base rounded. Aperture broadly obliquely ovate, subangled above. Peristome continuous,

outer edge thin, inner margin thickened. Columella oblique, rounded, same colour as shell. Inner lip with thin callus. Umbilicus represented by a chink. Operculum horny, thin, transparent. with numerous transverse curved striae, crossed by longitidunal irregular curved fine ridges; nucleus submarginal, of about 2 turns, and nearer the base.

Diameter (major), 1·5 mm.; height, 2 mm. Angle of spire, about 70°.

Animal unknown.

Holotype and several paratypes in author's collection.

Habitat.—Near Russell, Bay of Islands (A. E. B.).

Situation: Under loose boulders, partly embedded in sand.

I have very much pleasure in naming this small shell in honour of Mr. T. Iredale, for kind assistance rendered at various times. This species is not common: only about a dozen specimens were obtained after several days' collecting on a stretch of coast half a mile long.

ARCA Linné, 1758, *Syst. Nat.*, vol. 10, p. 693.

Arca sociella n. sp. (Plate 102, figs. 4, 4*a*.)

Shell very small, subrhomboidal, equivalve, inequilateral, costate. Anterior and posterior slopes rounded. Ligament long, narrow, extending well behind beaks. Umbones prominent, beaks a little incurved, well separated and situated about anterior fourth. Anterior end short, obliquely rounded, posterior end larger; dorsal margin angled behind, winged; posterior margin obliquely descending, produced; anterior margin with a few crenulations, and posterior broadly crenulated within, extending a short distance along ventral margins; basal margins straight, ventral irregularly rounded. Sculpture consisting of radiating rounded costae, more distant anteriorly, crossed by close concentric narrow well-defined striae, which produce, especially on posterior portion, a bold nodulous sculpture. Colour light yellow-brown, interior pale cream, shining. Hinge-plate moderately wide, narrower in middle, and curved. Teeth small, oblique, situated on either side of beaks, slightly curved, not at all distinct. Adductor-scars unequal, anterior pyriform, posterior ovate and larger. Pallial line simple. Dorsal area from beaks towards the posterior margins rather deeply excavated on either side, being broadly rounded, leaving dorso-posterior margins of valves arcuate.

Length, 5 mm.; height, 2·2 mm.

Holotype and paratypes in author's collection.

Habitat.—Near Russell, Bay of Islands (A. E. B.); type: Doubtless Bay (A. E. B.): Great Barrier Island (A. B. W. Powell).

Situation: Living in small colonies attached to boulders partly embedded in sand.

In sculpture this shell resembles *A. metella* Hedley, from Tasmania, but the contour of the two species differs considerably.

Descriptions of Six New Species and a New Genus of Gasteropod Mollusca from Northern New Zealand.

By A. W. B. POWELL.

[*Read before the Auckland Institute, 25th November, 1924; received by Editor, 22nd December, 1924; issued separately, 5th May, 1926.*]

Plates 103, 104.

WITH the exception of the large and handsome *Calliostoma*, the species described in the following paper are of small size. For two remarkable Rissoids it has been found necessary to propose a new genus. Another genus and a subgenus new to the New Zealand fauna are also represented.

The writer is indebted to Mr. R. A. Falla and Mr. W. La Roche for samples of shell-sand and dredgings, and to Mr. H. J. Finlay for permission to describe a species he also had separated out as new.

Genus CALLIOSTOMA Swainson, *Shells and Shell-fish*, 1840, p. 351

Type: *Trochus zizyphinus* L.

Considerable variation in the sculpture of the common *Calliostoma punctulatum* is noticeable when large series are examined. The number of the ribs remains fairly constant, but their relative strengths vary. The majority of specimens collected from kelp and clean rocks have 7 prominent primary ribs, the remaining 5 forming interstital riblets of varied size. Specimens from muddy localities, however, are much paler in colour, and more finely and uniformly sculptured, due to the primary ribs becoming smaller, and the interstital riblets larger until they almost equal the former in strength.

Calliostoma punctulatum appears to be the direct ancestor of the new species described below.

Calliostoma osbornei n. sp. (Plate 103, figs. 1, 2.)

Shell acutely conical, solid, imperforate. Outlines straight. Whorls 10½, body-whorl angled at periphery. Protoconch of 1½ smooth and globular whorls. Second and third post-nuclear whorls with 3 spiral ridges. A fourth spiral ridge develops at suture of fourth post-nuclear whorl, and during the next few whorls 2 more spirals are gained, with a maximum of 6 at the penultimate whorl. All spiral ridges conspicuously beaded. Interstitial riblets, when present, very faintly indicated; absent in most specimens. Base convex, with 10–11 spiral granular ridges. Axial sculpture consisting only of dense oblique growth-lines. Colour chestnut-brown, ridges dark brown with the granules cream or whitish. Suture not deep. Spire high, almost twice the height of aperture. Aperture rhomboidal, nacreous, and lirate within. Outer lip thin. Basal lip thickened with a nacreous callus. Inner lip spreading over parietal wall as a thin transparent nacreous glaze. Columella oblique, arcuate, with a slight tubercle at base. Operculum horny, multispiral with central nucleus as in *punctulatum* but more closely coiled.

Diameter, 34 mm.; height, 27·5 mm. Diameter, 33 mm.; height, 26 mm. (holotype). Diameter, 31 mm.; height, 25 mm. Diameter, 28·5 mm.; height, 24 mm.

Holotype and three paratypes in author's collection, Auckland. A number of specimens in possession of residents of Great Barrier Island.

Habitat.—Off Cape Barrier, Great Barrier Island, in about 27 fathoms; some from the stomach of the common snapper, *Pagrosomus auratus* (Forster). Named in honour of Mr. C. Osborne, of Tryphena, who has collected the species on numerous occasions.

This species is quite constant, and is easily distinguished from *punctulatum* by the straight outlines, much taller spire, greater number of whorls, and different sculpture consisting of fewer primary ribs and with the interstitial riblets absent or only faintly indicated. (See Plate 103.)

Genus LIOTINA Fischer, *Man. de Conch.*, 1885, p. 831.

Type: *L. gervillei* Defrance.

Liotina tryphenensis n. sp. (Text-figs. 4–6.)

Shell small, almost flat above, rounded below and widely umbilicate. Whorls 3½, very rapidly increasing. Protoconch smooth, of 1 whorl. Post-nuclear whorls sculptured throughout with strong close and radiating striae. Body-whorl tricarinate. Two rounded spiral keels, one above and the other below periphery, are connected with heavy axial varices, nodulous where they join spiral keels. These varices are absent from greater part of dorsal area of body-whorl, but are again resumed just behind aperture. A third rounded spiral keel at periphery is noticeable where body-whorl is devoid of axial varices. Where crossed by these varices central keel is almost suppressed, and appears only as a convex space between upper and lower keels. Ten varices on body-whorl, two of which are behind aperture. A series of irregular axial basal ribs project as teeth into umbilicus. Suture impressed. Aperture circular with a smooth continuous inner margin, strengthened by an interrupted heavy concentrically-striated outer lip, which terminates as a projection towards umbilicus. Umbilicus perspective, deep and wide. Operculum horny, concave, multispiral, with a central nucleus in the form of a small pit. Colour uniformly light brown.

Diameter—major, 3·2 mm.; minor, 2·5 mm. Height, 1·5 mm.

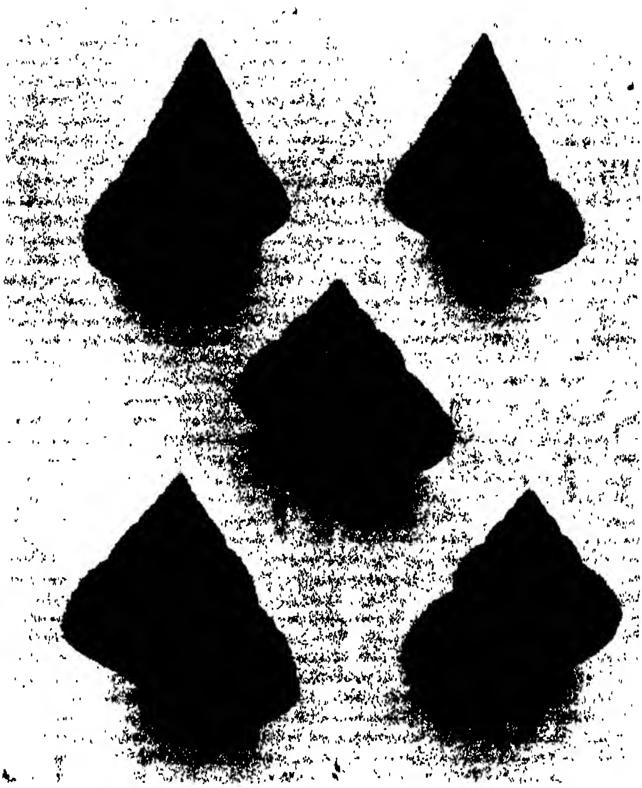
Holotype and one paratype in author's collection, Auckland.

Habitat.—Tryphena, Great Barrier Island, on under-side of stone at low water (coll. A. W. B. P., January, 1924).

It was suggested to the writer by Mr. H. J. Finlay that possibly this species was identical with Suter's *Liotia serrata*. Iredale considered both *Liotia solitaria* and *L. serrata* of Suter juveniles of the genus *Angaria* (1). The first-mentioned species Miss Mestayer has proved to be the juvenile of *Astraea heliotropium* (Martyn) (2). With regard to *L. serrata*, one of Suter's figures (3) is undoubtedly that of an adult shell, having a variced mouth and other characters typical of *Liotina*.

Both Mr. Finlay and the writer are of the opinion that *serrata* is here correctly placed, and that Iredale was wrong in classing it as the juvenile of *Angaria*.

As Suter's figure of *serrata* is a poor one, and his description rather meagre, the differentiating characters between *tryphenensis* and *serrata* are given below.



1. *Calliostoma osbornei* n. sp. (paratype).
2. *Calliostoma osbornei* n. sp. (holotype).
3. *Calliostoma punctulatum* Martyn, Titirangi, Manukau Harbour (muddy locality).
4. *Calliostoma punctulatum* Martyn, Reotahi, Whangarei Heads (on kelp).
5. *Calliostoma punctulatum* Martyn, Tryphena, Great Barrier Island (on seaweed).

Turbonilla finlayi n. sp.

The interrupted axial sculpture of *tryphenensis* is quite a distinctive feature. The holotype, measuring 3·2 × 2·5 × 1·5 mm., has 25 nodulous projections on the spire and body-whorls, 2 of which are just behind aperture. Major diameter of shell at commencement of denuded portion of body-whorl is 2 mm. The paratype, 2·9 × 2·1 × 1·25 mm., has 23 of the nodulous projections, 2 of which are behind aperture, as in holotype. Major diameter at commencement of denuded portion of body-whorl is 1·5 mm. This shows that the interrupted sculpture is a permanent feature, the denuded portion occupying the same relative area and position in specimens of different size.

In *L. serrata* the projections or denticles are confined to periphery of the flat whorls above, and are neither interrupted nor are they connected as in *tryphenensis* by axial varices with the lower carina. Also, *tryphenensis* is distinctly tricarinate, while *serrata* has only one rounded carina below and a sharp angle at periphery above, from which the denticles project.

Miss Mestayer's *Liotia suteri* (4) would also be better placed in *Liotina.*

Genus PROMERELINA n. gen.

Type: *Promerelina crosseaformis* Powell.

A Rissoid genus evolved from *Merelina* (5), having a differently sculptured protoconch, and remarkable basal characters superficially resembling *Crossea.* The three basal spirals of *Merelina* have in this genus resolved into a single strong basal plate arising from suture, just behind aperture, and terminating at base of peristome. The columella also differs from *Merelina* in being free and projecting below. The protoconch, spirally striate in *Merelina*, is in this genus sculptured with granular spiral ridges. The sculpture of the post-nuclear whorls, clathrate in *Merelina*, differ also, due to the axial ribs becoming obsolete, leaving the spiral sculpture as prominent keels. In the genotype sufficient of the axial ribs remain to render the spiral keels nodulous at the points of intersection, but in *P. coronata,* the second species of the genus, the axial sculpture is entirely wanting. Protoconch and basal characters identical in both species, which differ so much from typical *Merelina* and all other known Rissoids that the author feels quite justified in proposing a new genus for these unique shells.

Promerelina crosseaformis n. sp. (Text-fig. 2.)

Shell very small, clathrate. Whorls 5½. Protoconch of 1½ convex whorls, sculptured with 10 granular spiral ridges. Succeeding whorls with 2 strong spiral ridges crossed by faint regularly-spaced axial ribs produced into nodules at points of intersection. A third smooth strong spiral ridge arises from suture just behind aperture and terminates at base of peristome. Columella vertical, with an indistinct fold above (which is more apparent in the larger decollated Whangaroa specimen), free and projecting below. Suture deep. Aperture oblique-oval. Peristome continuous, double on the outer edge from suture to base of columella, and produced at termination of the three spiral ridges.

Height, 3 mm.; diameter, 1·25 mm.

Holotype in author's collection, Auckland.

Habitat.—Maro Tiri (Chicken Island), (type), in shell-sand (coll. R. A. Falla, December, 1923); Whangaroa—one specimen (coll. W. La Roche, February, 1924).

Promerelina coronata n. sp.

Shell very small. Whorls $5\frac{1}{2}$. Protoconch of $1\frac{1}{2}$ convex whorls, sculptured with 10 spiral granular ridges. Succeeding whorls abruptly angled at periphery and produced into a smooth lobed lamellar ridge with an upward tilt. Whorls smooth above but spirally striate below ridge. A deep spiral groove at periphery separates ridge from sculptured lower portion of whorls. Suture deep. Colour pale buff. Columella subvertical with an indistinct fold, free and projecting below. Aperture and basal characters similar to those of the foregoing species. A single strong spiral basal plate arises from suture just behind aperture and terminates at base of peristome. Outer lip thickened and produced at termination of spiral ridge and basal plate.

Height, 3 mm.; diameter, 1·5 mm.

Holotype in author's collection, Auckland.

Habitat.—Maro Tiri (Chicken Island), (type), in shell-sand (coll. R. A. Falla, December, 1923): Rangaunu Bay, in 12 fathoms (two imperfect specimens from dredgings by Mr. W. La Roche, May, 1924).

Genus Turbonilla Risso, subgenus Turbonilla s. str., *Hist. Nat. Eur. Mer.*, vol. 4, 1826, p. 224.

Type: *Turbonilla typica* Dall and Bartsch = *T. plicata* Risso, 1826, *Bull. 68, U.S. Nat. Mus.*; Dall and Bartsch, *West American Pyramidellid Mollusks*, p. 29.

Turbonilla finlayi n. sp. (Plate 104.)

Shell small, elongate-conical. Colour dull-white; fresh specimens semitransparent, with a narrow opaque band immediately below suture, caused by base of preceding whorl showing through, giving the appearance of a margining of suture. Sculpture consisting of numerous close straight and flattish axial riblets with much narrower interstices; those on upper whorls almost linear. Axial ribs continue right to base of body-whorl but become indistinct and mostly bifurcate after passing periphery. Interstices above periphery lightly channelled, grooves terminating abruptly at periphery. Axial ribs on body-whorl varying from 42 to 46; the holotype has 44. Whorls 7, plus a sinistral convoluted heterostrophe protoconch of 2 smooth whorls, with a lateral nucleus. Spire high, about $2\frac{1}{4}$ times height of aperture. Suture deep. Outlines of whorls very little convex, and slightly shouldered immediately below suture. Aperture oblique, elongately oval, angled above and rounded below. Peristome discontinuous, thin and sharp, terminating in a thin callosity, spreading broadly over parietal wall. Columella arcuate.

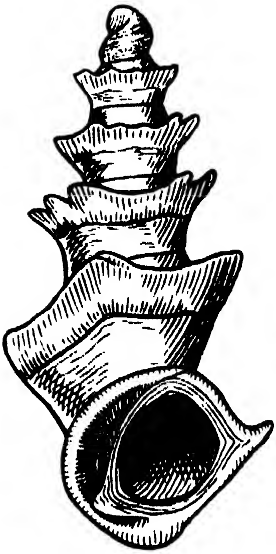
Dimensions: 5·2 × 1·75 mm. (holotype); 5·0 × 1·62 mm.; 4·87 × 1·5 mm.; 4·80 × 1·45 mm.; 4·5 × 1·4 mm.

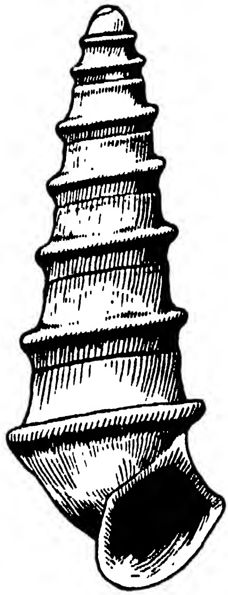
Holotype and several paratypes in author's collection, Auckland.

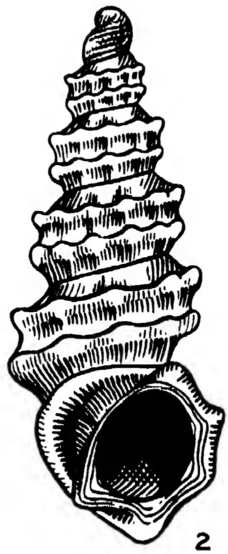
Eight adult and two juvenile specimens from Rangaunu Bay and Awanui Heads collected by Mr. W. La Roche; two decollated specimens from Stewart Island, lent by Mr. H. J. Finlay.

Habitat.—Awanui Heads (type), washed up on beach; Rangaunu Bay, in 12–15 fathoms; Stewart Island.

Dall remarks that usually in *Turbonilla* s. str. both ribs and intercostal spaces are less strongly defined on the base below the periphery than on the







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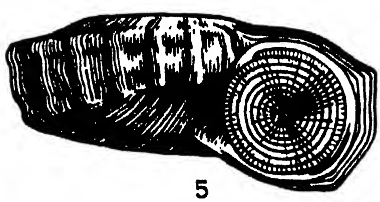

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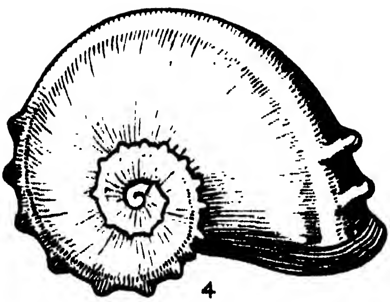

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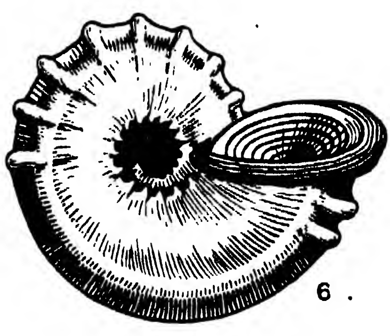

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FIG. 1.—*Promerelina coronata* n. sp.
FIG. 2.—*Promerelina crosseaformis* n. sp.
FIG. 3.—*Teretianax pagoda* n. sp.
FIGS 4, 5, 6.—*Liotina tryphenensis* n. sp.

exposed portion of the whorls above it. No doubt this is caused by light channelling of the intercostal spaces above the periphery, as in *T. finlayi.*

Of the four Recent species of *Turbonilla* found in New Zealand, *T. finlayi* is the first of the typical section. *T. zelandica* Hutton has the axial ribs stopped at the periphery, with the base smooth. Thus *zelandica* really belongs to the subgenus *Chemnitzia*, as Hutton originally placed it, and not to the typical section as classed by Suter. A second species of *Chemnitzia*—*T. lamyi* Hedley (6) -has been described from Macquarie Island. The fourth Recent *Turbonilla*—*T.* (*Pyrgolampros*) *blanda* Finlay (7) —represents still another subgenus.

Genus TERETIANAX Iredale, *Proc. Mal. Soc.*, vol. 13, pts. 1, 2, August, 1918, p. 39.

Type: *Scalenostoma suteri* Oliver, *Trans. N.Z. Inst.*, vol. 47, 1915, p. 533, pl. 11, fig. 30.

Teretianax pagoda n. sp.

Shell small, white, surface smooth, sides straight with a single prominent spiral keel. Whorls 7. Protoconch bluntly rounded, smooth, of 1 whorl. The following whorl with 2 spiral ribs, the lower one the more prominent. On the succeeding whorls the upper rib rapidly diminishes, forming only a faint margining of suture, and finally disappears, while the lower rib gains in strength, forming a prominent heavy spiral keel. Suture impressed. Aperture oblique, narrowly rounded below and angled above, with an indentation above shoulder. Peristome continuous over parietal whorl as a thickened callosity.

Height, 2·5 mm.; breadth, 0·9 mm. (holotype).

Holotype and three paratypes in author's collection, Auckland.

Habitat.—Tryphena, Great Barrier Island (type), in shell-sand (coll. A. W. B. P., January, 1924); Maro Tiri (Chicken Island), in shell-sand (coll. R. A. Falla, December, 1923); Rangaunu Bay, in 12 fathoms (three specimens from dredgings by Mr. W. La Roche, May, 1924); Mongonui Heads (four specimens from dredgings by Mr. W. La Roche, June, 1924).

This makes the second known species, and also adds a genus to our fauna. The genotype is from Sunday Island, Kermadec Islands.

The genotype of *Scalenostoma* Deshayes, *S. carinatum* Deshayes, from the Isle of Bourbon, figured in *Structural and Systematic Conchology*, Tryon, 1883, vol. 2, pl. 68, fig. 95, shows that that genus has a small protoconch and that the peristome is retracted towards the suture.

Both species of *Teretianax* have a comparatively large rounded nucleus, and peristome is only slightly indented above shoulder. Iredale considers *Teretianax* a doubtful member of the Eulimidae (8).

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The Maori Craft of Netting.

By TE RANGI HIROA (P. H. BUCK), D.S.O., M.D., Ch.B.

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Plates 105–114.

INTRODUCTION.

IN Polynesia the ancestors of the Maori depended largely upon fish to augment their food-supplies. In spite of the larger land area of New Zealand, there were no indigenous mammals, with the exception of two kinds of bat. These were not large or numerous enough to be of any food value. The dog, which the Maori brought with him, was eaten, but, the supply being limited, it served only as a luxury for people of rank. The rat, which also accompanied the immigrants, multiplied on the berries and roots of the forest. It was trapped, preserved in its own fat, and esteemed as a delicacy. Owing to its size, however, it was of little importance, quantitatively, in the dietary of the people. The pig, known in Polynesia, never reached New Zealand until the coming of Captain Cook. Though the forests, lakes, lagoons, and outlying islets teemed with bird-life that supplied their quota to the neolithic larder, it was the fish of the sea, rivers, lakes, and streams that provided the Maori with the greater portion of his flesh foods. Thus we find the population mainly established along the sea-coast, with extensions up the river-valleys and around the shores of the larger lakes.

The methods of procuring fish were based upon the careful observations of generations of fishermen, who studied the habits, food-supplies, and seasons of the various fish frequenting the waters that formed an important part of the tribal territory. To the Maori the area covered by a lake or river was as important for food-producing purposes as fertile strips that were unsubmerged by water. On the coast, the value of his domain did not cease at high-water mark, but extended to the sands, rocks, reefs, and far-out submerged feeding-grounds where the finny Children of Tangaroa assembled in their appropriate seasons. The times of their movements and migrations to feed or spawn were well known, and influenced method and invention. Always the Maori caught for the cooking-oven and the storehouse. Though he felt the fisherman's thrill in making a good catch, it was always as a means to an end, and not the wasteful end itself, as is so often the case with his European neighbour.

The indiscriminate dropping of a baited line in the hope of hooking anything that came along is rightly regarded by the Maori as the action of a *kuware*—a person devoid of practical sense. The European solar calendar, whilst utilized in many directions, seems to be but little used as a guide as to when various fish are both plentiful and in good condition. The Maori unwritten lunar calendar marked the seasons of appropriate food-supplies on land, or in water, whether salt or fresh. The rains of

autumnal March sent the eels migrating down the rivers and streams on their way to the deep-sea spawning-grounds. The white flowers of the *manuka* and the yellow gold of the *kowhai* conveyed definite information to those who could read. The luxuriant growth of the *kohuwai* seaweed brought the well-conditioned *kehe* up the rocky channels of the favoured reefs. Thus from Nature's calendar the neolithic fishermen received their orders as to what traps, nets, or hooks to select, and what spot to seek on inland river, coastal reef, or deep-sea fishing-ground. The careless leaving to chance marks the degradation of barbaric culture and the advent of a higher civilization.

Scope of Article.

Fish were caught with hook and line, seine-nets, a variety of smaller nets, and with various kinds of traps. Different methods exist amongst the various tribes owing to local conditions. In this article the smaller nets are dealt with, and the large seine-nets avoided for the time being.

Locality.

These notes were mostly gathered from the Ngati-Porou Tribe of the east coast of the North Island. Their territory extends from north of Gisborne to Lotin Point. Owing to the kindness of the Hon. A. T. Ngata, M.P., a party from the Dominion Museum, consisting of Messrs. Elsdon Best, J. McDonald, and J. C. Andersen, made an ethnological expedition to the district in 1923. The Ngati-Porou people extended hospitality and gave every assistance in supplying information. I had the good fortune to be in the district at the time, and to be able to assist the expedition in compiling these notes. Many of them were gathered at Waiomatatini and Rangitukia, in the Waiapu Valley, and at Te Araroa, on the coast. In addition, previous notes obtained from the Whanau-Apanui Tribe, who occupy the neighbouring stretch of coast in the Bay of Plenty, have been made use of. Though descended from the "Mata-atua" canoe, the Whanau-Apanui are related by blood to the Ngati-Porou, and have a similar culture. This stretch of coast, extending from north of Gisborne to Hawaii, a few miles from Opotiki, is characterized by reefs which attract a large variety of fish. The deep sea also teems with fish. Hence the district is rich in fishing-material.

NETTING-MATERIAL.

Phormium tenax (*Harakeke;* New Zealand Flax).—The suitability and ease of preparation of the *Phormium tenax* made it unnecessary to use other fibrous material for nets. For some types of net the dressed fibre was used. Two-ply strands of scraped fibre (*muka*, or *whitau*) were twisted into neat cords on the bare thigh. The usual material, however, consisted of narrow strips from leaves of undressed flax. The Maori craftsman, in netting as in other crafts, took a pride in his work, and gave of his very best in careful detail as well as in manipulative dexterity. Skilled netters selected not only a particular kind of flax, but took great care in picking particular leaves. The thickness and consistency of the blades were tested by feeling with the fingers before they were cut. They were then hung up inside a shed for a couple of days before use. They were thus partly dried without being too hard, and the netting-knots did not loosen, as would

happen if freshly-cut flax were used. The blade was split with the thumbnail into strips from ⅛ in. to ¼ in. in width. Even strips of the same consistency in the leaf were necessary to ensure good, even netting. The thick, stiff butt end of the flax-blades being discarded left the individual strips from 3 ft. to 4 ft. long. No further preparation was needed with the strips. A requisite supply of strips were split off the flax-blades, the free edges and midrib being, of course, discarded. The strips were placed in a heap beside the netter, the butt ends being towards him.

For the framework, hoops, and handles of the nets the following were usually used :—

Rhipogonum scandens (*Kareao* or *Pirita* ; Supplejack).—This is a climbing creeper, and makes ideal hoops for bag-nets. It is easily split, and makes an arched handle for crayfish-nets. Split lengths also make elastic spreaders for the *torehe* trap.

Leptospermum scoparium (Manuka).—This shrub produces long, tough poles, which form excellent handles for scoop-nets and the bag-net known as *tutoko*. Poles of *manuka* are also used to make the framework of the trap-net for the *kehe* fish.

Phyllocladus trichomanoides (*Toatoa* or *Tanekaha* ; Celery-topped Pine).—This grows into a large tree, but when young supplies excellent poles, used as handles in scoop-nets for *kehe* and fishing-rods for *warehou*.

Aristotelia racemosa (*Makomako* ; Wineberry).—Poles from this tree are also used as handles, but, whilst it is lighter than the previous two, it is more liable to break.

Dysoxylum spectabile (*Kohekohe* ; Maori Cedar).—Long poles are used as a framework in the *kehe* trap-net.

(NOTE.—In further references to these plants the Maori name will be used.)

TECHNIQUE OF MAORI NETTING (*TA KUPENGA*).

The generic name for any kind of net is *kupenga*, and the process of netting *ta*. Thus we have *ta kupenga*, net-making. The various kinds of nets have their individual names, which may be a distinct word or a descriptive word added to *kupenga*. The Maori used no netting-needle. As most of the nets were made with short strips from the undressed blade, the work proceeded quickly enough, and there was no incentive to use a needle. Wooden mesh-gauges, called *papa*, were used, but in the East Coast district the fingers of the left hand were usually used instead of the mechanical gauge. As the actual technique of these smaller nets is very similar, the general technique of making a bag-net will be dealt with first, and then the various kinds, with their differences. The making of nets and fish-traps was the occupation of men, just as plaiting and weaving was that of women.

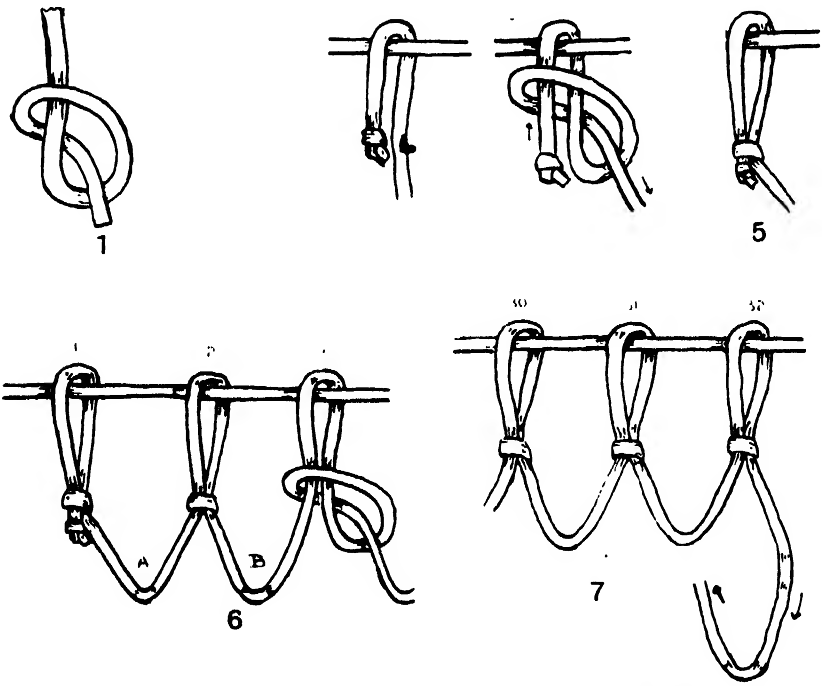
SUPPORTING-STRAND (NGAKAU).

All circular bag- or funnel-shaped nets are commenced on a loop or supporting-strand, called a *ngakau*. A strip of green flax about 2 ft. or more long is knotted together at the ends to form a large loop. This is stretched over the foot or great toe of the netter, who sits on the ground with a bundle of strips of flax beside him. In commencing a net, the first step is to set up the required number of loops on the supporting-strand. In the district under review there are four methods of setting up the loops to commence a net.

Methods of Commencement.

(1.) *The Closed-loop Commencement.*

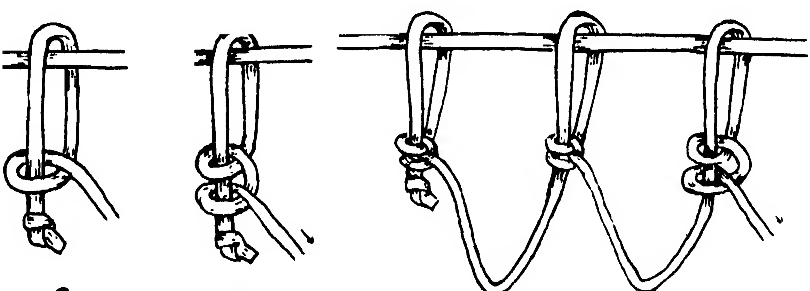
A strip of flax is taken up and knotted at the butt end with a simple overhand knot (figs. 1, 2). The butt end of the strip is looped over the supporting-strand and the knotted end brought down about 1 in. below it (fig. 3). The double strip is held together at the knot with the left hand. With the right hand the free part of the strip is looped to the right, passed over both strands to the left, passed under both and brought up through the bight or loop on the right (fig. 4). This is drawn tight, and the first closed loop is made (fig. 5). It will be seen that this is but a repetition of the overhand knot, differing only in the knot being made over two strands



Figs. 1–7.—Closed-loop commencement, with overhand knots.

instead of one as in fig. 1. The free end of the netting-strip is passed over the supporting-strand and the middle finger of the left hand hooked under the large loop formed. By pulling with this finger the size of the loop is gauged. If drawn too large the free end of the strip is pulled with the right hand to reduce the size. Thus by pressure with the left middle finger and pulling with the right hand the size of the loop is adjusted. The left thumb and forefinger now come across and grasp the ascending and descending parts of the netting-strip 1 in. below the supporting-strand. Keeping the two together, the right hand makes a bight to the right, passes over both limbs, back under and up through the bight—or, in other words, makes a second overhand knot. This is drawn tight, and the second closed loop is completed (fig. 6). Reference to the figure shows that from the two short closed loops

made round the supporting-strand a larger open loop, A, depends. These larger loops are important, as it is to their lower points that the next row of real meshes will be attached by the true netting-knot. The shorter closed loops (fig. 6, 1–2) are made so as to set up these longer loops on the supporting-strand. It is important to have them, as well as the upper closed loops, of even size. On commencing the third closed loop the left forefinger is slipped under the completed lower loop A, and when the netting-strip is carried over the supporting-strand the left middle finger is inserted under the new lower loop B. The middle finger pulls until the loop B is of the same length as A. The left forefinger is slipped out of loop A, and with the thumb grasps the double strand, 3, 1 in. below the supporting-strand, whilst the right hand makes the overhand knot. In this way the third closed loop, 3, is formed and the second lower loop, B. The process is continued in this manner until the requisite number of closed loops are made, thirty-two being a convenient number for the smaller bag-nets. With thirty-two closed loops there will be thirty-one lower loops; but when the net comes to be joined at the end of the process a thirty-second longer loop will be formed between the first and last closed loops.



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FIGS. 8–10.—Closed-loop commencement, with clove hitches.

The netting works from left to right along the supporting-strand, and ever the left forefinger slips along into the completed lower loop and the middle finger gauges the new loop. The middle finger may be used in the completed loop and the new loop gauged with the ring-finger. In this case the forefinger is free to come over and hold the double strip for the closed upper loop ere the overhand knot is tied. The thirty-second closed loop having been made, the set is complete. The netting-strip now turns back to commence the second row on the lower points of the lower loops (fig. 7).

As a variation to this method, in the Te Kaha district the upper closed loops are tied with a clove hitch instead of an overhand knot. The process is quite simple. The netting-strip having been looped over the supporting-strand, the double strip is brought together 1 in. below and held together as before with the left forefinger and thumb. The free part of the strip is passed over the ascending limb to the left, brought back under it and between the limbs to form the half-hitch, as in fig. 8. A similar half-hitch is made immediately below the first, and a clove hitch results, as in fig. 9. This is continued throughout (fig. 10). The advantage is that when drawn tight a clove hitch will not slip like an overhand knot. The overhand knot, however, is made more quickly; and in this commencement any slight slipping does not matter much.

In the figures, the closed loops on the supporting-strand are shown as spaced apart for the sake of clearness. In actual netting the work lies horizontally, and from pulling on the loops to gauge their size the loops are stretched and crowded close together on the supporting-strand (see Plate 105, fig. 2).

(2.) *The Clove-hitch Commencement.*

In the variation of the previous method the closed loops are made with a clove hitch. In this method the closed loops are not used, but the large loops are fixed directly to the supporting-strand by a series of clove hitches. The only name I could get for a clove hitch was *here poito taruke* (the tie of the float of the crayfish-pot). The floats of *houama* (*Entelea arborescens*) are tied with this knot to the long rope marking where the crayfish-pot (*taruke*) has been put down.

The netting-strip is passed round the supporting-strand, brought over the ascending strip from the left, looped over the supporting-strand again on the right, and the free end of the strip brought up through the loop, as

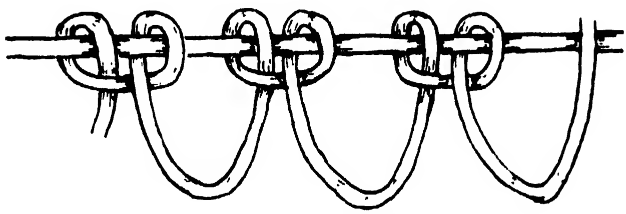


Fig. 11.—Clove-hitch commencement.

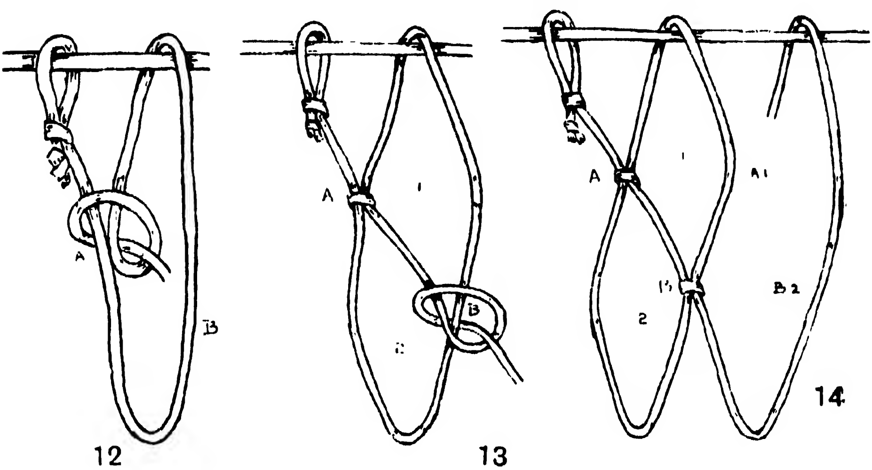
in fig. 11. In this manner the loops are attached directly to the supporting-strand. The loops between the clove hitches are gauged as before with the left fingers. The required number of loops are set up, and then the netting proceeds as in method (1). When the net is completed the supporting-strand is cut and removed. This releases the clove hitches, which open out to form the free upper angles of the first row of meshes.

(3.) *The Double-mesh Commencement.*

The butt-end of the first netting-strip is fixed to the supporting-strand by a closed loop with an overhand knot, as in fig. 5. The netting-strip is then looped over the supporting-strand, and the loop pulled with the left middle finger until it is judged long enough to make two full meshes. Keeping the netting-strip taut with the right hand, bring it against the left *limb* of the loop at the lower end of the upper third at the point A in fig. 12. Grasp the two elements at this point with the left thumb and forefinger, and with the right hand make an overhand knot as in the closed-loop commencement. Still keeping the loop stretched with the left middle finger, bring the netting-strip against the right limb of the loop at the lower end of the middle third at the point B in fig. 13. Again tie an overhand knot, and the long loop is divided into two complete meshes—1 and 2 in fig. 14. The netting-strip is again carried over the supporting-strand and the tip of the left ring-finger is inserted under the new loop. The left middle finger, still hooked in the lower part of mesh 2, stretches the original first loop, whilst the ring-finger pulls on the new loop

until the lower ends of both coincide. The netting-strip is brought against the left limb of the loop—*i.e.*, against the side of mesh 1 at A1, on the same level as point A, and an overhand knot is made. This strip is then carried down against the right limb of the loop at B2 on the same level as B, and an overhand knot made. The second loop is thus divided into two complete meshes. This process is continued until the requisite number of meshes have been set up on the supporting-strand.

This is a quick, easy way of commencing a net: When the first long loop is stretched, divide it with the eye into three equal parts. The first knot is tied at the junction of the upper two parts, and the second at the



FIGS. 12–14.—Double-mesh commencement.

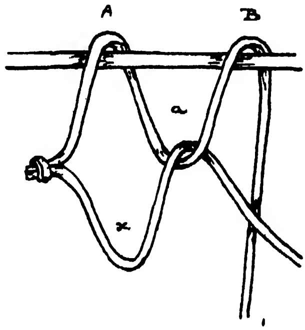
junction of the lower two. This ensures meshes of even size. In the subsequent long loops see that the lower ends are brought to the same level, and keep the same lines of knots, A and B, accurately on their respective levels. By attention to these details an even mesh will be maintained throughout.

(4.) *The Double-strip Commencement.*

This method was shown me by Iehu Nukunuku, of Waiapu, one of the very few surviving musicians who can play the Maori flute. I had mastered the above three methods, and was confident that I had exhausted all local methods of commencement. Whilst practising the closed-loop method one early morning, the dreamy gaze of the musician idly swept my way. Suddenly his eyes became alert. "Ah," said he, treating me politely as a master-craftsman, "You commence that way!" "Yes," I affirmed, with the conscious pride of one who has missed nothing. "Oh," said he, "I do it this way." Thereupon he picked up two strips of flax, knotted the butt ends together, and demonstrated the double-strip commencement shown in the accompanying figures.

In fig. 15, the upper strip, 1, is looped over the supporting-strand at A and looped again at B. The lower strip, 2, is passed over the loop between A and B. The mesh so formed, *x*, is stretched to the right size by the left middle finger, the free end of strip 1 is held with the right hand, and the

free end of strip 2 is held with the left thumb and forefinger. The two strips are pulled or slackened until the mesh *x* is of the right size. The part where the two strips cross is seized with the left thumb and forefinger, and the right makes a netting-knot with strip 2, as in fig. 16. This completes the first mesh, *x*. Strip 1 is now carried over the supporting-strand at C (fig. 17). It picks up strip 2 in the loop. Inserting the left ring-finger in the loop *y*, and manipulating the two strips with the other available fingers of the two hands, the two loops *b* and *y* are gauged to correspond in size to *a* and *x*. The free end of strip 1 is then twisted round the left little finger to keep loop *b* in position. The point where strip 2 crosses the lower part of loop *b* is seized with the left thumb and forefinger, and the released right hand ties strip 2 in a netting-knot at this point. The netting-knot will be described in the next paragraph. This procedure is carried on. When the upper loop is gauged, strip 1 is kept taut by twisting it round the



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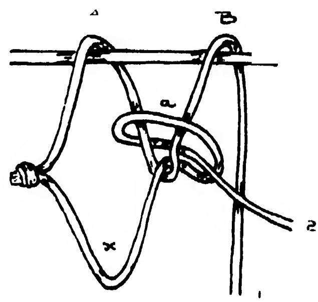

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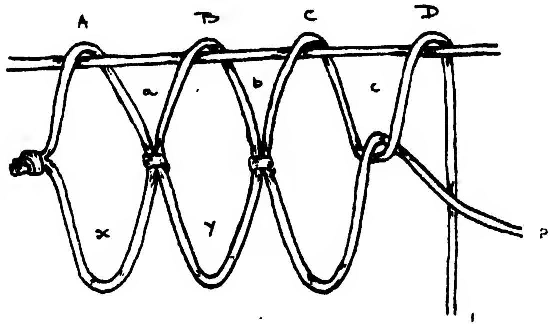

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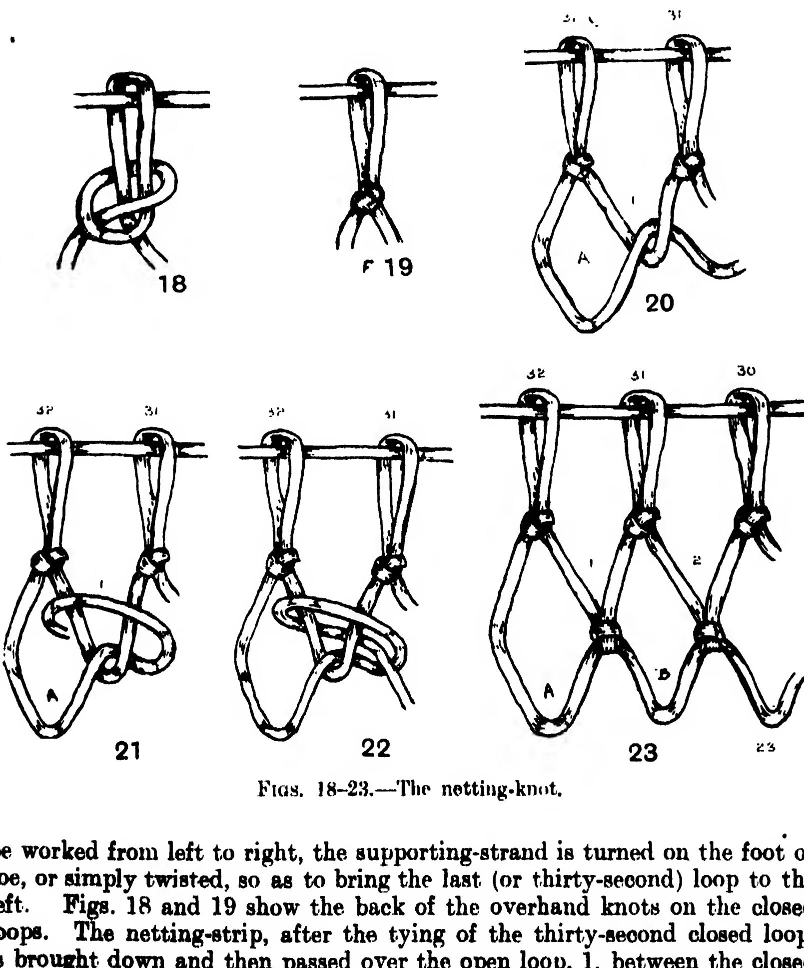
Figs. 15–17.—Double-strip commencement.

left little finger. This releases the right hand, which now takes the free end of strip 2 from the left forefinger and thumb. The lower loop is now gauged with the left ring-finger, the left middle finger keeping the previously-completed mesh stretched so as to give the lower level for the new lower loop. This being gauged, the released left forefinger and thumb seize the crossing of the two strips, whilst the right hand makes the netting-knot with strip 2. Strip 1 is then released from the left little finger and looped over the supporting-strand, and the same process continued. In this method

a single row of complete meshes is attached directly to the supporting-strand. The method is awkward, and is worse than it reads. Practice makes perfect, no doubt, and in the fingers of Iehu Nukunuku it appeared neat and easy. I had asked my previous informants if there were any other methods, and had been assured that there were none to their knowledge. Possibly if one practised in the early morning with aged musicians or craftsmen looking on, other methods or variations might be resurrected. Therefore it were better to put on record what methods we have than wait for others that we know not of.

THE NETTING-KNOT.

Taking the closed-loop commencement already described, we have seen that after the thirty-second loop has been made in the supporting-strand the second row is commenced with the netting-knot. As all netting must



FIGS. 18–23.—The netting-knot.

be worked from left to right, the supporting-strand is turned on the foot or toe, or simply twisted, so as to bring the last (or thirty-second) loop to the left. Figs. 18 and 19 show the back of the overhand knots on the closed loops. The netting-strip, after the tying of the thirty-second closed loop, is brought down and then passed over the open loop, 1, between the closed loop 32 and 31. A full-sized mesh is gauged by pulling with the left middle

finger as in fig. 20, A. The lower part of loop 1 is seized between the left thumb and forefinger, and the netting-strip where it crosses is pinched, as it were, between the two limbs of the loop. This is held securely so as to maintain the size of the mesh whilst the netting-knot is made with the right hand. The right hand makes a bight to the right with the netting-strip (fig. 21). The strip is then carried over both limbs of loop 1, passed behind them, and brought up through the bight (fig. 22). The left hand continues its hold until the knot is drawn taut and the netting-knot is completed (fig. 23). See also Plate 105, fig. 2.

The movements of the netting-strip are thus similar to those in the closed-loop commencement—a loop or bight to the right, over, under, and up through the bight. The difference is that in one case the netting-strip, being turned back on itself, forms an overhand knot, and in the other case, through being made over a loop, it results in the netting-knot. The netting-knot is similar to the weaver's knot, but is tied in a different way. The Maori netting-knot is the same as the usual European one except that in the latter the netting-cord is passed through the loop from below and the bight is made to the left. This is the opposite to the Maori method, but the results are the same.

The first full mesh being completed, the netting-strip is carried over the next loop, and the resulting loop is gauged with the left ring-finger to the same lower level as the first completed mesh, which is still stretched by the left middle finger. The netting-knot is made as described above, and completes a second full-sized mesh. So the process goes on, the half-loops, as it were, completing the lower halves of full-sized meshes, whilst the intervals provide the upper halves for the meshes of the next row. At the end the supporting-strand is turned, and the next row commenced with a full-sized mesh from the left. Owing to the turning of the supporting-strand, the commencing full-sized meshes are alternately at either end or side of the piece of netting. Furthermore, except for the first and last rows of meshes, each mesh has a knot at each of its four angles. The alternate commencing mesh has only three knots, and the outer sides are free. This is important, as we shall see later.

Owing to the turning of the work at the end of each row, one set of alternate rows of knots will show the front aspect of the knots, whilst the other set will show the back.

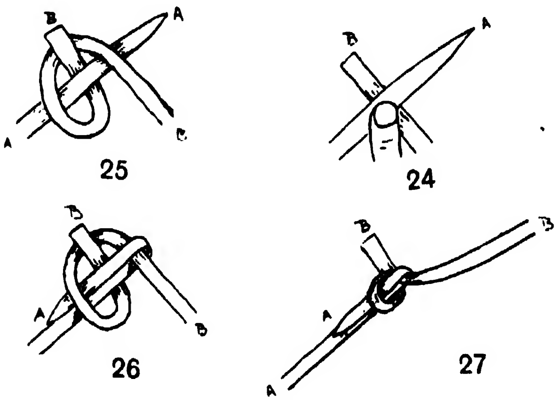
Joining the Netting-strips.

The netting-strips are in short lengths, owing to the thick butt part of the blade having been discarded. When the tip ends of the strips begin to thin off, a new strip is added to maintain the even appearance as well as the strength of the net. There are two methods of adding the netting-strips:—

(1.) *Knotting the Strips together.*

When the netting-strip becomes too short to complete the next mesh the butt-end of a fresh strip is knotted to it. The two may be placed together and an overhand knot tied with them both. The usual knot, however, is the weaver's knot, for which I could get no Maori name. It is the common knot used by the Maori in joining two strips together. As it is made in a quick, neat way, the following details are given: The butt end of the additional strip is crossed under the end of the shortening-strip.

The crossing is held in position with the left thumb and forefinger, the thumb being above (fig. 24). The free part of the new strip, B, is looped over the thumb-nail, passed under its own projecting butt-end, and back over the old strip, A, as in fig. 25. The end of the old strip, A, is doubled back over

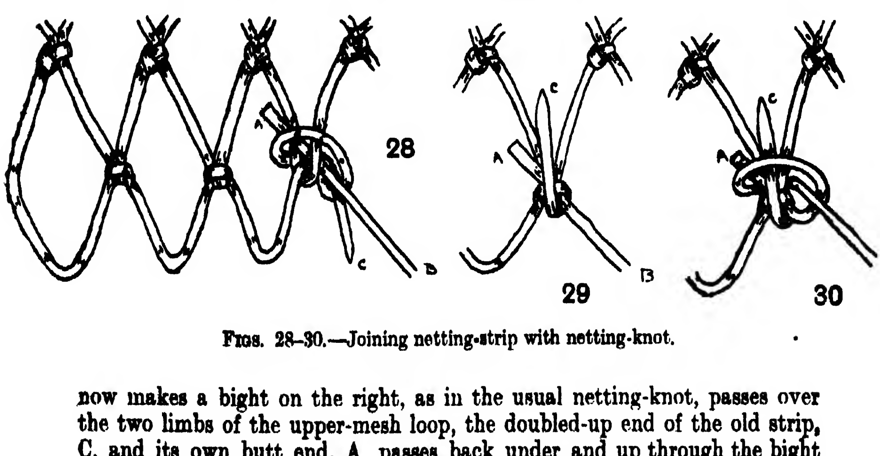


FIGS. 24–27.—Joining netting-strip with weaver's knot.

B and held down on itself with the left thumb (fig. 26). Holding the doubled-back strip, A, firmly with the left finger and thumb, the new strip, B, is pulled, and the loop tightened into the knot shown in fig. 27.

(2.) *Joining at a Netting-knot.*

This method is the better of the two. With the shortening-strip the last netting-knot is not drawn taut. The butt end of the fresh strip is pushed through the loose knot and between the two limbs of the upper mesh loop, as in A, B, fig. 28. The end of the old strip, C, is pulled tight to close the loose knot, and is then bent upwards (fig. 29). The fresh strip



FIGS. 28–30.—Joining netting-strip with netting-knot.

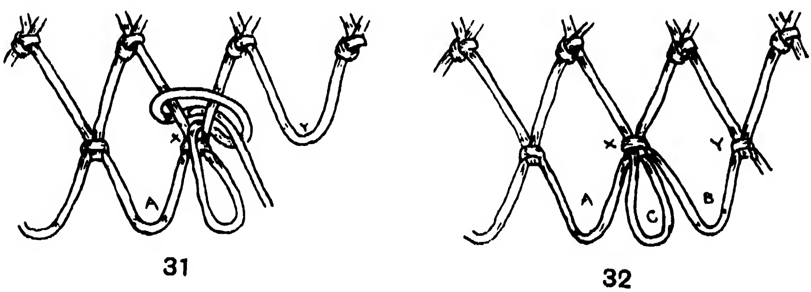
now makes a bight on the right, as in the usual netting-knot, passes over the two limbs of the upper-mesh loop, the doubled-up end of the old strip, C, and its own butt end, A, passes back under and up through the bight (fig. 30). It is drawn tight and the two ends trimmed off. In this process two netting-knots have been made.

Additional Meshes (Mata Torea).

In the making of bag or scoop nets the bottom of the net is usually smaller than the diameter of the opening. In the East Coast area this is done by adding meshes to various rows as the work proceeds. This means that the thirty-two meshes set up on the supporting-strand will ultimately be at the bottom of the net, whilst the addition of, say, sixteen new meshes will give the lowest row forty-eight meshes to form the opening of the net. These extra meshes are called *mata torea*—*mata* being the term used for mesh. The *mata torea* are added in two ways:

(1.) *Complete Mesh.*

In this method, when it is desired to add a new mesh, instead of the netting-strip going on to the next loop it simply adds a small mesh to the knot just made. Thus in fig. 31, after making the netting-knot at X, instead of going on immediately to the loop Y, the strip is carried over the same loop upon which the knot has just been tied at X. This loop is gauged with the left ring-finger to bring the lower end to the same level as the previous loop, A. The new loop itself is small, but this is immaterial so long as the lower level is the same. The strip now makes a bight to the right, passes



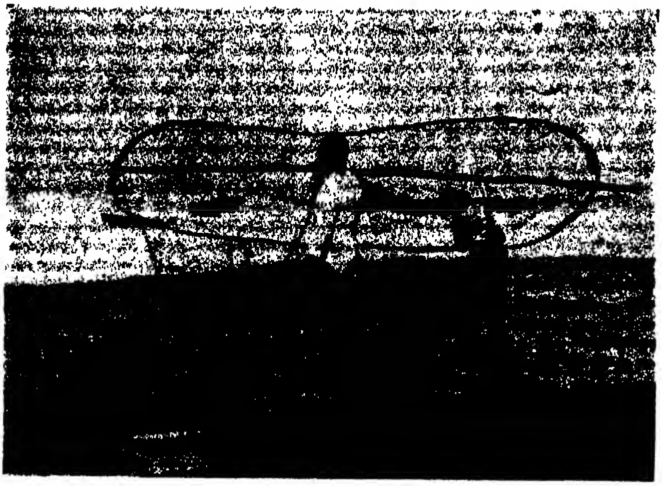
FIGS. 31, 32.—Additional meshes.

over both limbs of the loop, and comes up from behind through the bight to complete the ordinary netting-knot as shown in the figure. The netting-strip now passes on to the next loop (fig. 32).

The result is that an extra loop, C, has been inserted between the usual loops, A and B. When the next row is being made, instead of one mesh being made between A and B, two will be formed. One will be made between A and C, and the other between C and B. The row is thus increased by one mesh.

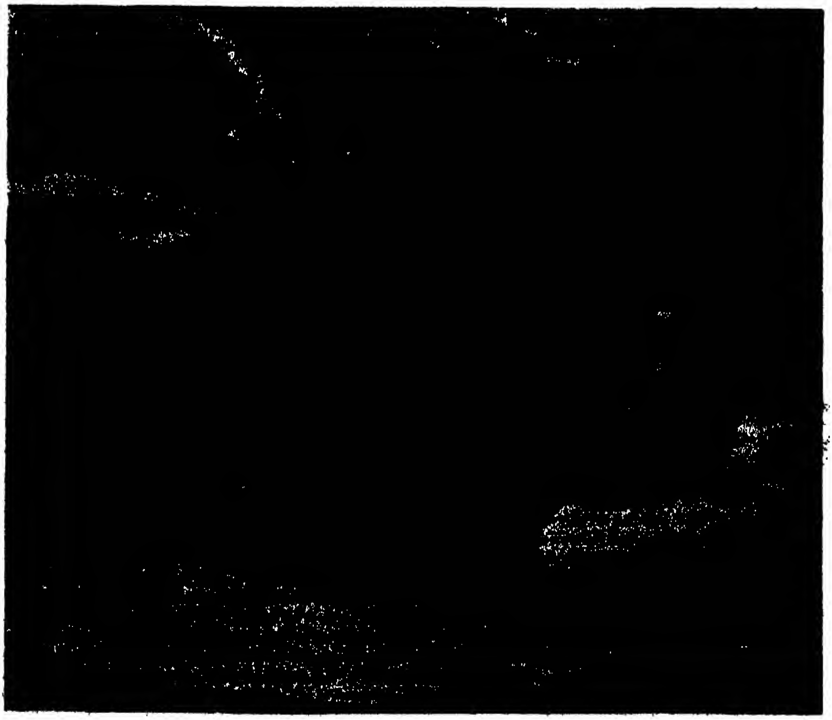
(2.) *Two Half-meshes.*

This method presents a much neater appearance than the former one. In fig. 33, instead of carrying the netting-strip from the loop A to the loop B to make one complete mesh, as in the ordinary routine, this mesh-space is divided up into two. The strip, after making the netting-knot at A, is carried up over the netting-knot of the row above at X. The loop formed is gauged to the same level as the previous loop. The strip is carried down to the level of the lower ends of the loops of the last row at A, B. At this point, Y, the ascending and descending limbs of the netting-strip are held with the left finger and thumb whilst an overhand



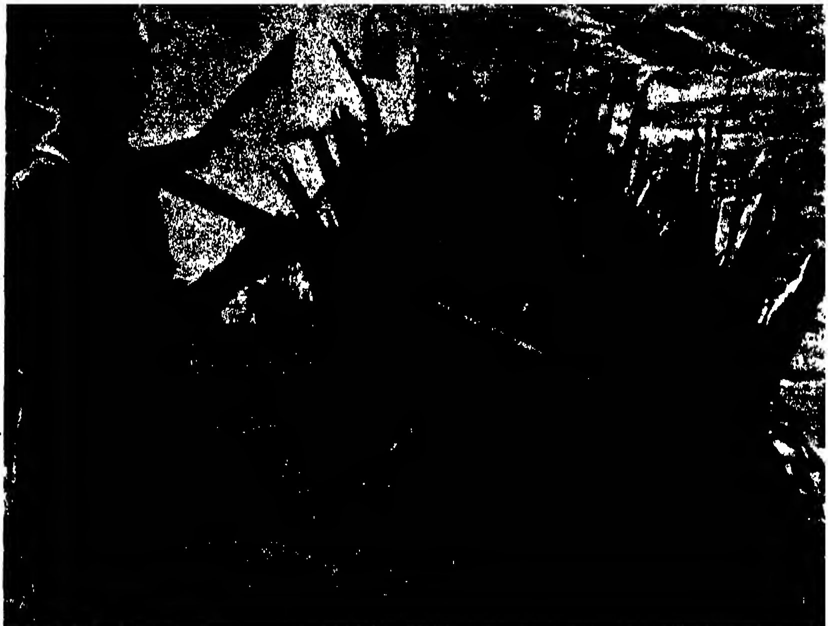
[J. McDonald, photo.

FIG. 1.—Scoop-net for *kahawai*: beach at mouth of Waiapu River. (See p. 620.)



[W. R. Reynolds, photo.

FIG. 2.—Net-commencement: closed loops on supporting stand; author gauging mesh.



[J. McDonald, photo.

FIG. 1.—Scoop-net for *kehe*: note *au*, for threading fish, in right hand. (See p. 612.)
FIG. 2.—*Kehe* fishers on Wharepongs beach: in pairs—one with net, the other with *kōkō* pole. (See p. 616.)

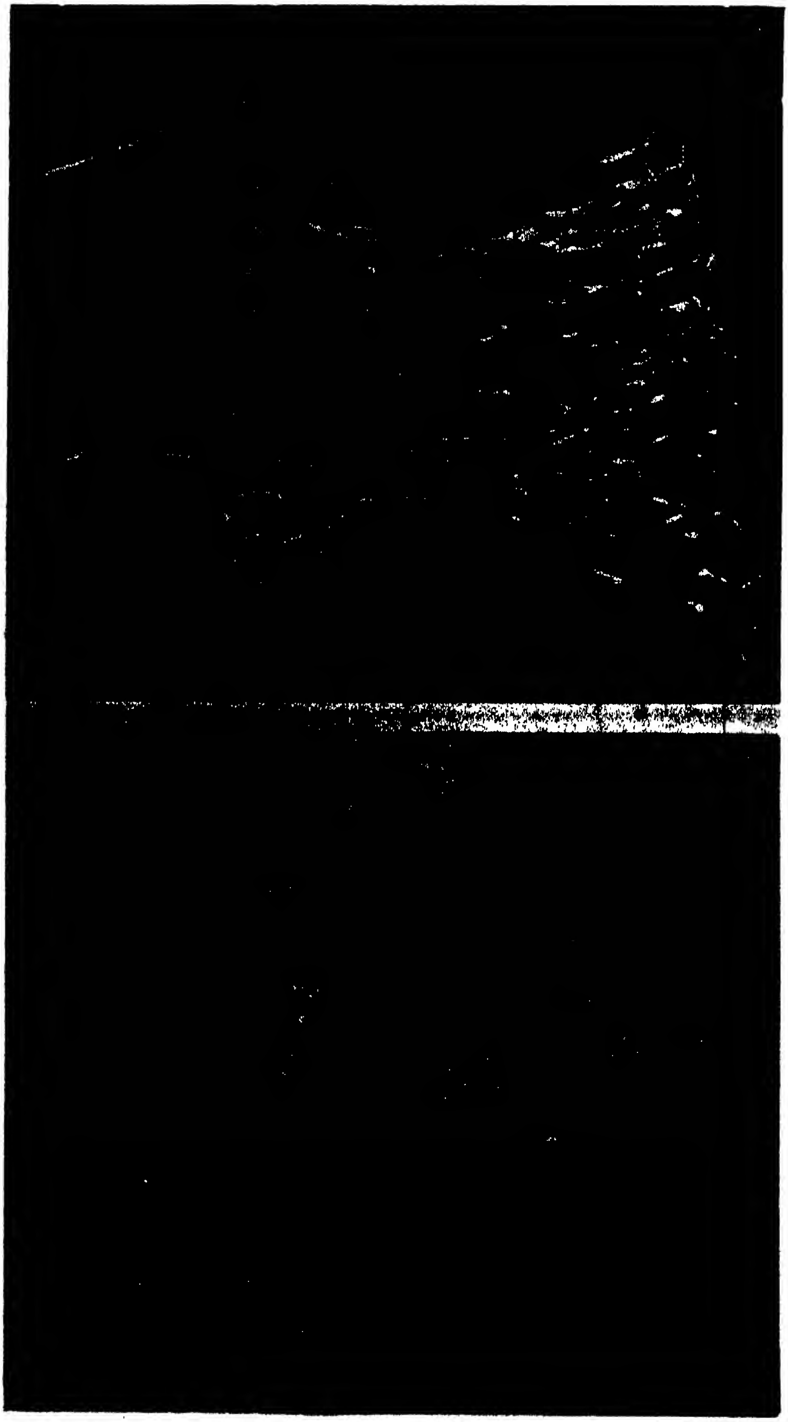
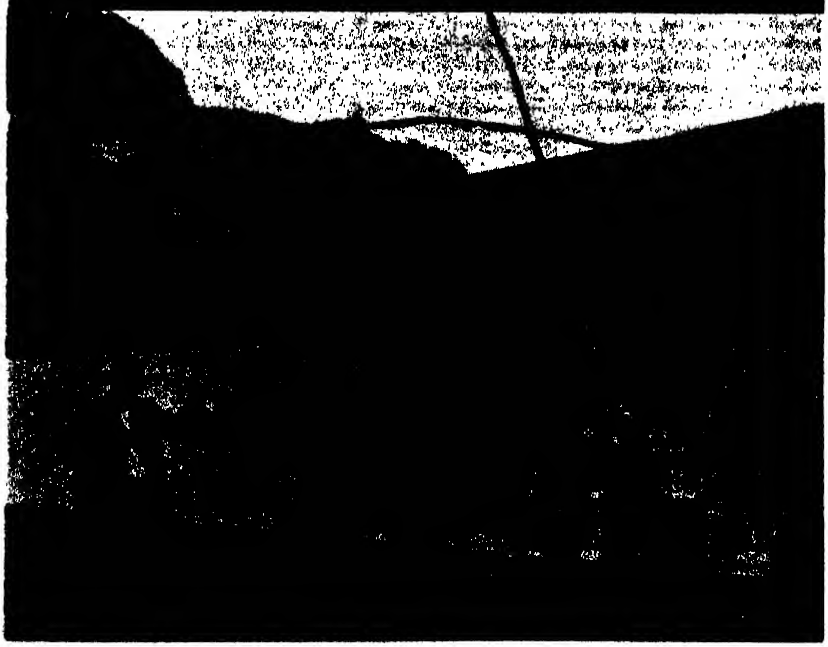
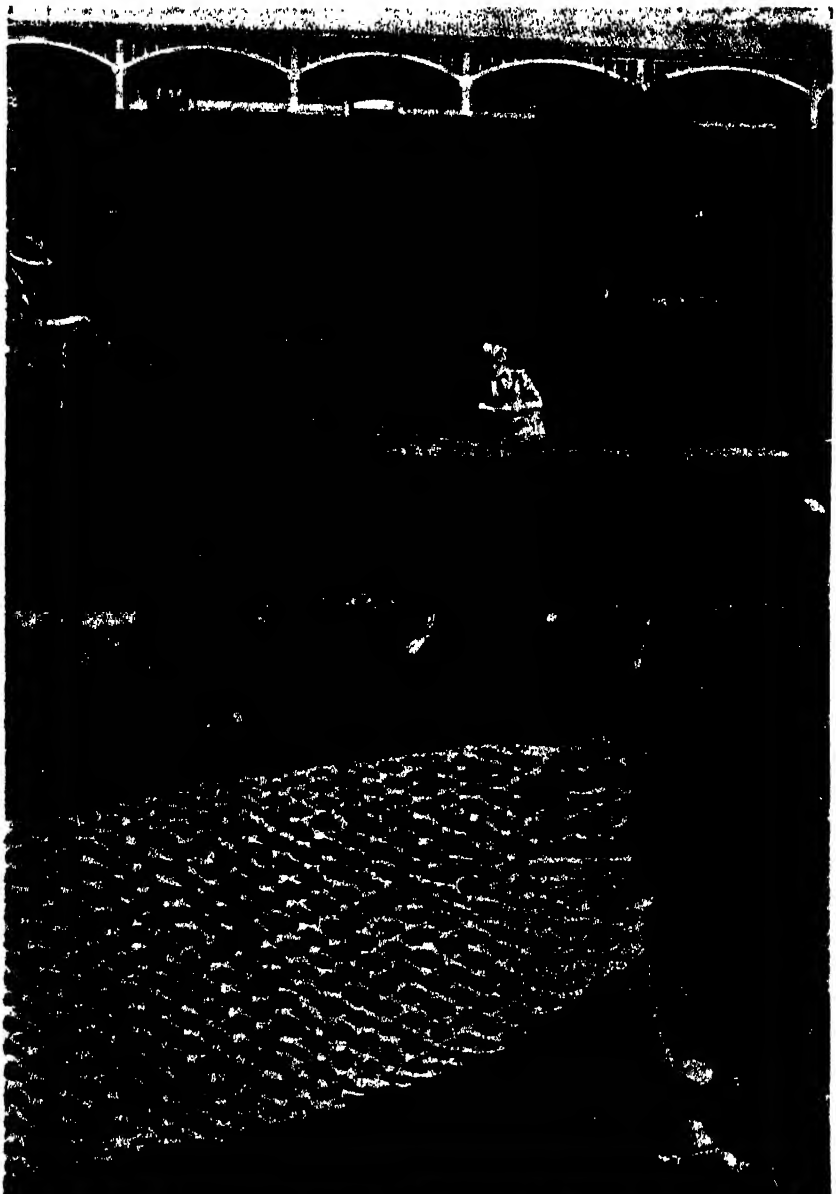


FIG. 1.— for cray : crab sho site. p. 626.)
FIG. 2.— with fork handle for ha. see p. 630.



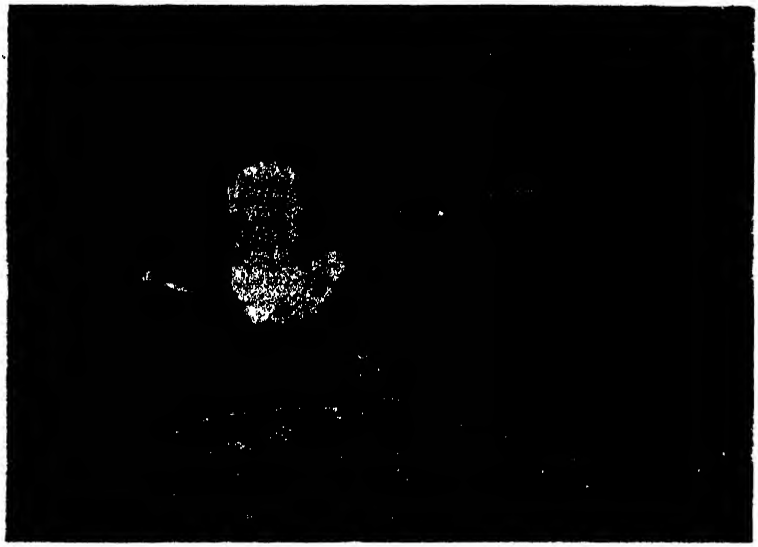
[J. McDonald, photo.

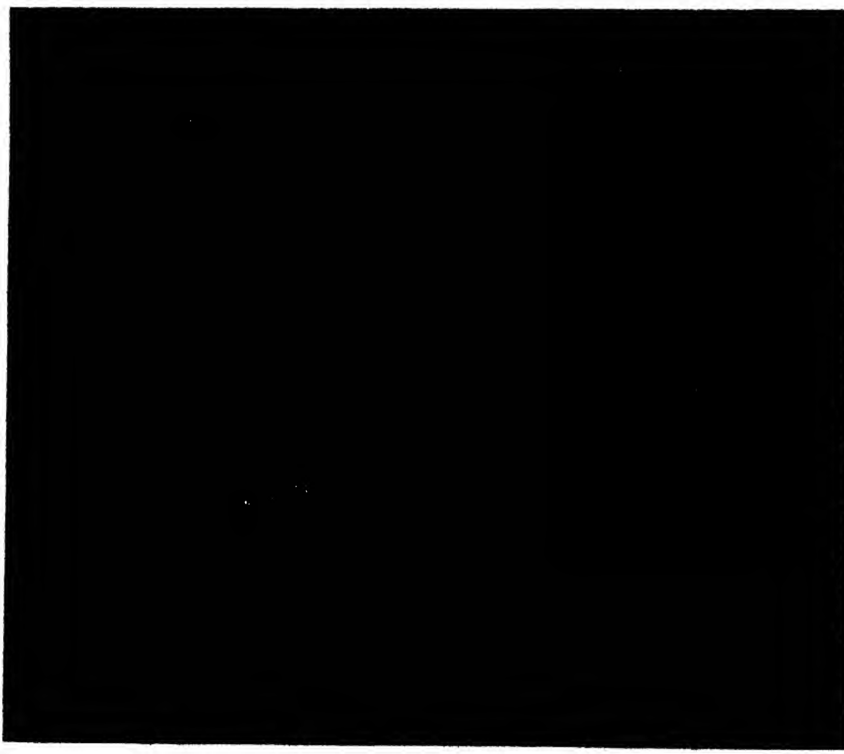
FIG. 1.—*Matarau* net: upper eight radiating lines support the hoop; lower four are for bait. (See p. 632.)
FIG. 2.—Large *matarau* net for *maomao*, used off Lotin Point. (See p.. 631)



[J. McDonald, photo.

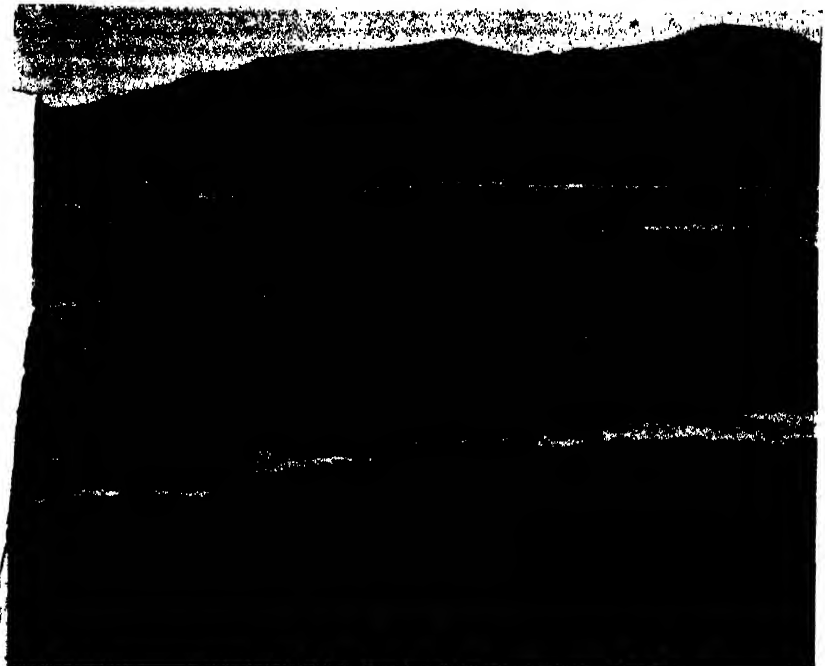
FIG. 1.—*Hinaki purangi*: trap and leading-net in one. (See p. 640.)
FIG. 2.—*Hinaki purangi*: small end where net is commenced. Loop of flax tied when net is set, and untied to extract catch. (See p. 641.)





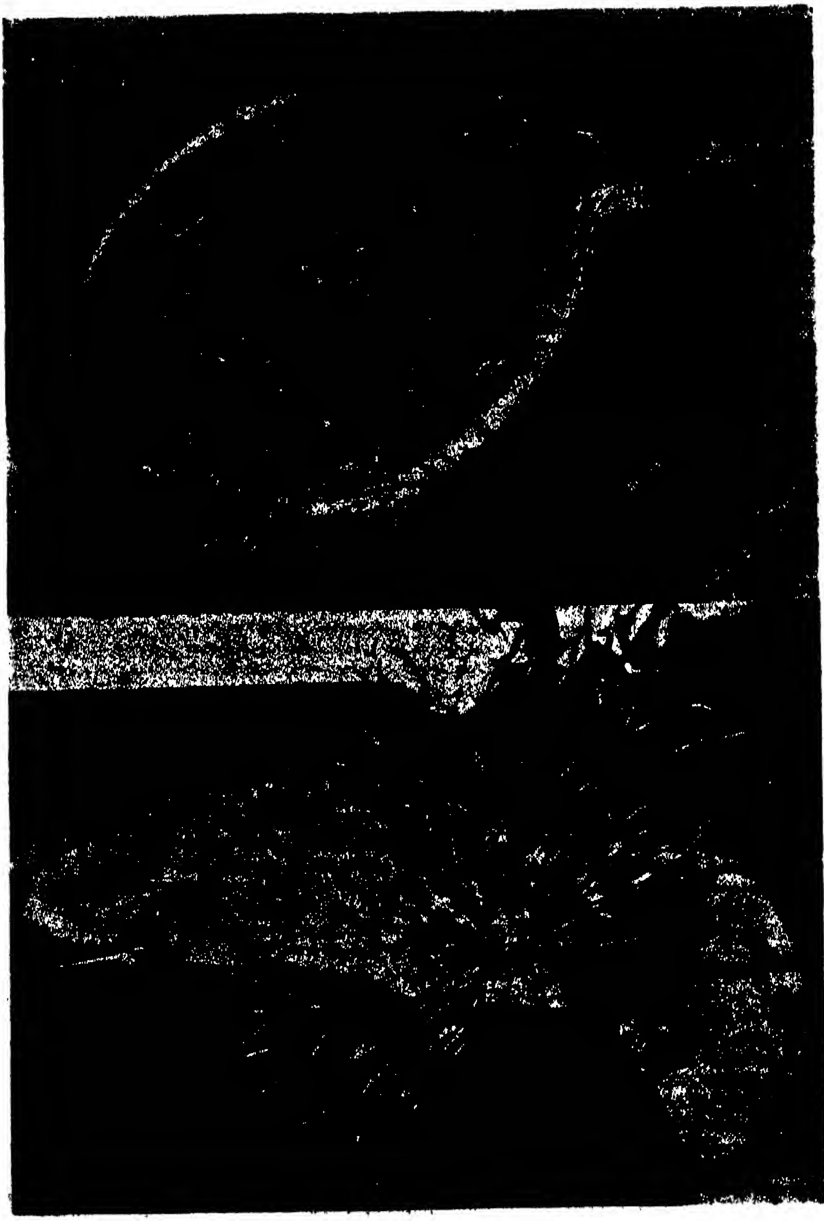
[J. McDonald, photo.

FIG. 1.—Attaching a leading-net to an eel-trap (*hinaki*). (See p. 639.)
FIG. 2.—*Hinaki* with leading-net set in weir, Waiapu River. (See p. 642.)



[J. McDonald, photo.

FIG. 1.—Side view of *hinaki purangi*, set in Waiapu River. (See p. 641.)
FIG. 2.—Looking down into above *hinaki purangi*. Note brushwood arms of weir. (See p. 641.)

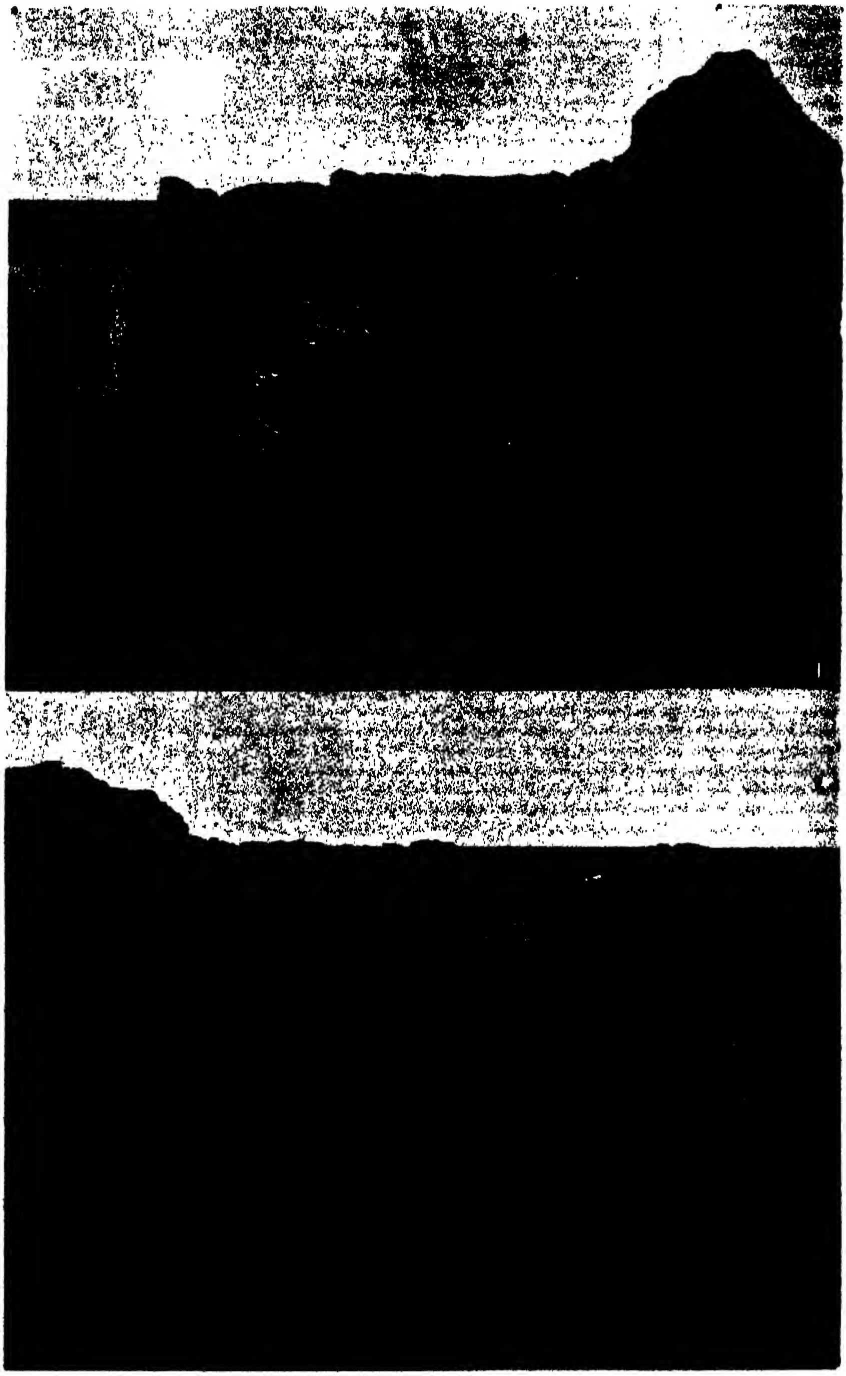


[J. McDonald, photo.

Fig. 1.—Landing-net for *warehou*. (See p. 623.)
Fig. 2.—*Torehe* net being made: supporting strand over foot; gauging-mesh on left. (See p. 643.)

[J. M

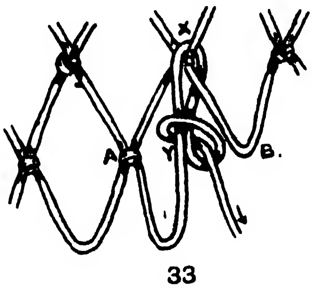
FIG. 1.—B trap-[illegible] (*torehe*), showing als, circumferential bai and sinker at l Loc Arama.
FIG. 2.—T net cl by pulling line : er gives the counter e pp. 645–646

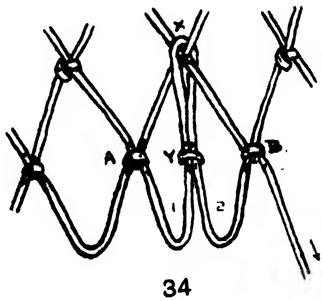


[Rev. Canon Pahewa, photo.

Haua, or *hinaki kehe*. Locality, Te Kaha. (See p. 635.)

knot is made over both, as in the closed-loop commencement. The netting-strip is now looped over the next mesh, B, and after gauging the loop to the same level as mesh 1 the ordinary netting-knot is made at B. This completes the mesh 2 in fig. 34. Thus two meshes, 1 and 2, have taken the place between A and B that by the routine method would have been occupied by one mesh, and the row is thus increased by one.





FIGS. 33, 34.—Additional mesh (second method).

JOINING THE SIDES.

When the net has been made deep enough, the next stage is to close up the sides by joining the marginal meshes together. If the netting is removed from the supporting-strand, stretched, and laid out flat, a four-sided figure is produced. The upper (commencing) and lower borders are parallel, but owing to the introduction of additional meshes the lower border is much longer. The upper border commenced with, say, thirty-two loops or meshes, and the lower ended with perhaps forty-eight meshes. The side borders therefore diverged downwards and outwards, but, owing to the loops being made of the same size and the netting-knots thus kept to the same levels, the number of meshes on the side borders is exactly the same. When the side borders are placed close together, parallel with each other, the lines of knots coincide. As a matter of fact, the netting is kept on the supporting-strand when the last row is completed. The two side edges are twisted round on the looped supporting-strand until the two sides lie parallel, as in fig. 35, where the two free edges, bounded above by the closed loops 32 and 1, are shown running down the middle of the figure.

It will be noted in the figure that each mesh is defined by four knots, except the meshes at the side (*i.e.*, each side of the middle gap in the figure) and the bottom. These have a free margin without the fourth knot. In the two side edges these meshes with a free margin have been caused by the netting-strip making a full mesh as it turned at the end of a row to knot back on the loops of the completed row. Thus the netting-strip, on completing the thirty-second supporting-loop, ended at *a*. To go back, it formed the full mesh A, and completed the second row of knots at *b*. It now formed the full mesh B and completed the third row of knots at *c*. The full mesh C was formed and the fourth row of knots completed at *d*. Then followed the full mesh D, the fifth row of knots finishing at *e*, the full mesh E, the sixth row of knots finishing at *f*, the full mesh F, and the seventh row of knots finishing at *g*. The free end of the netting-strip is marked NS.

All that has now to be done is to carry on with the netting-strip and put in a fourth knot on the marginal meshes, F, E, D, C, B, and A, in the order named. The procedure is simple. The left fore and ring fingers are inserted in the two lowest marginal meshes, J and F, and drawn taut. The netting-strip NS from the last knot *g* is looped over the left middle finger and drawn taut so that the new loop G will coincide with the lower margins of J and F. The strip is placed against the middle part of the free or unknotted margin of the mesh F, held together by the freed left forefinger and thumb, and an overhand knot made, as in the closed-loop commencement. It is the last knot of the seventh row, puts the fourth knot on the mesh F, and adds the new mesh G. From here the strip is carried across to the unknotted margin of E, and then in turn to D, C, B, A, and is finally knotted at the point Z on the first closed loop, 1. This is the only right way in which the net could be closed.

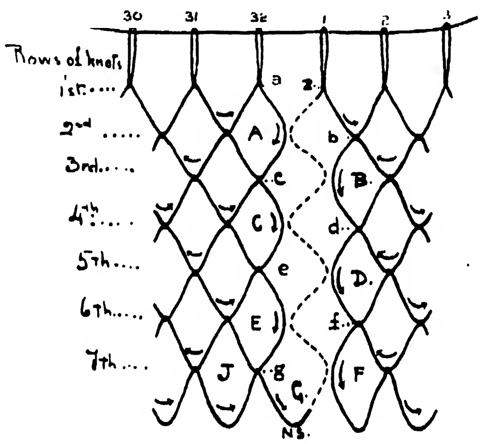


FIG. 35.—Joining of sides, indicated by zigzag dotted line.

We set out to get thirty-two meshes on the supporting-strand by putting thirty-two closed loops on it, but this only made thirty-one loops between them. The closure between the mid-point of A and Z, besides closing the net, adds the thirty-second loop, and all the way down the netting-strip not only completes the lines of knots, but completes the meshes. In pulling upon the lower marginal meshes, the point on the long, free, unknotted sides of the meshes brought beside the knot on the opposite side denotes clearly where the netting-strip is to be tied. Thus in the stretched meshes the knot *g* will be against the point where the new knot should be made. Similarly, in crossing from side to side, the length of the netting-strip between the knots corresponds to the length of the flax between the other netting-knots—namely, one side or one-fourth of a mesh. To sum up: the side meshes with only three knots have had the fourth knot put on by the netting-strip taking them in turn on either side. The lines of meshes are completed, and the net joined at the sides.

Our net, which at the end of the first stage was a rectangular figure, has now been converted into a funnel-shaped net with both ends open.

CLOSING THE BOTTOM OF THE NET.

The last stage in completing the bag-net is closing the smaller of the two openings of the funnel-shaped net. This, as we have seen, is the part that was commenced on the supporting-strand. The top part thus becomes the bottom. The closing is done in two ways:—

(1.) *Temporary Closure by Tying.*

In some nets it is an advantage to close the bottom of the net temporarily, in order that the catch of fish may be removed through it. This is especially the case in long or deep nets. For these nets the closed-loop commencement is preferred. The supporting-strand on which the closed loops have been set up is then simply drawn taut and tied with a knot which can readily be unfastened. This is seen in the end of the *hinaki purangi* (Plate 109, fig. 2), where the strand has been untied and the closed loops spread along it to show up the end of the net. It is also shown in the *matarau* and *hava* nets, which are dealt with later.

(2.) *Permanent Closure by Netting.*

When the commencement has been made with the clove hitch, double mesh, or double strand, the smaller opening to be closed consists of a marginal row of ordinary meshes. The method in closing is practically the same as that of closing the side edges, except that it is usual to use the netting-knot instead of the overhand knot or clove hitch. The supporting-strand is removed from the smaller end, and the other end hooked over the big toe by one of the meshes. A strip of flax is knotted at the butt end, and then fixed by the netting-knot to the mid-point of the marginal edge of any one of the sixteen circumferential meshes. It is best to take the one farthest away when the net is stretched. In fig. 36 this selected mesh is numbered 1, and the closing-strip shown by a broken line. From the first mesh, 1, the strip is taken to the mid-point of the neighbouring mesh on the left, 2, and then to the mesh on the other side of the first mesh —namely, 16. From now on the figure shows the netting-strip going from side to side until the last mesh, 9, is tied. In this way the opening is closed by stretching the net and bringing the sides of the opening together.

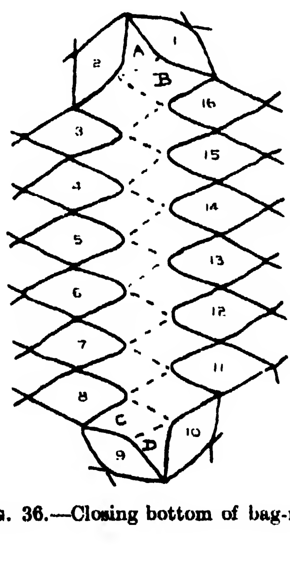


FIG. 36.—Closing bottom of bag-net.

The netting-strip between the free points of the meshes should be of the same length as between the knots on the meshes—*i.e.*, one-quarter of a mesh. In making the netting-knot on the free points of the marginal meshes the two side knots of the mesh should come together when the netting-strip is pulled. This exactly bisects the marginal half of the mesh. In this manner neat work is done, and the joining really adds two rows

of meshes of the same size as the others. They have all got four sides, and form perfect lozenges, except the first and last meshes made. When the netting-strip passed from mesh 1 to 2 it cut off a three-sided mesh, A. When the strip crossed from 2 to 16 it completed a four-sided normal mesh, B. These normal meshes are continued until the strip makes its last crossing from 10 to 9, when it completes a normal mesh, C, and cuts off the last three-sided mesh, D. These three-sided meshes form two corners, as it were, at each end of the closing-line at the bottom.

VARIETIES OF NETS.

For purposes of description we may divide the nets of the region under discussion into four classes :—

A. Scoop-nets : These are unbaited, have a rigid wooden handle, and are worked sideways.

B. Bag-nets : These are baited, and sunk by stone sinkers or a rigid handle. They are drawn up vertically by a cord or handle, when the fish make their presence known by pulling at the bait.

C. Set trap-nets : These are left in streams or channels without bait, and depend upon position and the current to effect the capture of fish, which, owing to the make of the net or the force of the water, cannot escape.

D. Baited trap-net : This is a baited trap which requires the personal attention of the fisherman.

A. Scoop-nets.

These nets are usually referred to as *korapa*, but the term *korapa* is particularly associated with a landing-net. The ordinary European landing-net for trout would be rightly termed a *korapa* in Maori. The net used on Lake Rotorua to lower under a fern-bundle in catching crayfish is called a *korapa*. In this series there are three varieties—for (1) *kehe*, (2) *kahawai*, (3) *warehou*.

KEHE.

(1.) *Scoop-nets for* Kehe (Haplodactylus meandratus (*Richardson*)); *Granite-trout*).

Kehe are very plentiful along the rocky shores of the East Coast and the eastern part of the Bay of Plenty. They feed on smaller forms of seaweed which grow in rocky channels and rocks close to the shore. Their movements are influenced by the seasonal growth of these marine algae. Thus seasons, tides, and local conditions as regards rocks and channels have influenced the form of scoop-net and the method of catching. There are three forms of scoop-net, and seven methods of catching.

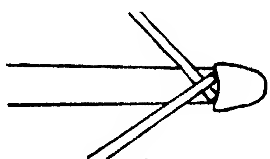
(*a.*) *Kupenga koko kehe.*—An example of this variety is shown in Plate 106, fig. 1. It is being held by Hemi Whangapirita, of Wharepongaa, who supplied much of the information under this heading. It consists of a long handle, hoop, net, and a circumferential cord which attaches the net to the hoop.

The handle, called *tango*, is made from a pole of *toatoa* 9 ft. to 10 ft. in length. Sometimes *makomako* wood is used: it is lighter than *toatoa*, but snaps more easily. In the example figured the handle is 6 ft. 6 in.

from the free end to the hoop, and 41½ in. within the hoop. Just above the hoop it is 5½ in. in circumference. The part within the hoop is scraped down to a lesser thickness, and at the lower end of the hoop it is shaped into a knob (fig. 37). The free end of the handle is sharpened to a point, which is used to drive off sting-rays.

The hoop (*whiti*) is made of a length of supplejack (*pirita*). A piece 9 ft. 6 in. long is bent into a hoop as shown in Plate 106, fig. 1. The two ends are crossed on the lower end of the handle, just above the knob (fig. 37). They are tied to the handle with a split strip of *pirita*, which is first warmed to render it soft and pliable for binding. This lashing lasts longer than flax. This end of the net is called *te putiki o te kupenga* (the knot of the net). The Whanau-Apanui call it the *nake*. The upper end of the hoop crosses the handle 41½ in. from the point, and it is tied with the slack of the circumferential cord. This gives the shape shown in the picture. The diameter of the hoop at the widest part is 29 in. If it is desired to narrow the hoop to fit a particular channel, the cord can quickly be untied and the upper end of the hoop drawn farther up the handle; it is then tied in the new position, and the diameter of the hoop thereby narrowed.

The net (*kupenga*) is made like the bag-net described. The size is counted by the number of meshes round the circumference. The usual net contains sixty-four meshes, or *mata*. The number must be even, so that



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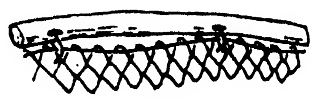

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FIG. 37.—Lower end of handle of *kupenga koko kehe*.
FIG. 38.—Attachment of net to hoop.

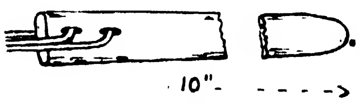
the net hangs right on either side of the handle. An odd number of meshes is called *tauwhara*, and indicates bad workmanship. The depth is measured from the outstretched finger-tips to the anterior fold of the armpit or to the tip of the shoulder—*i.e.*, from 22 in. to 30 in. This net is usually cylindrical, as no additional meshes, or *mata torea*, are added. The sides and bottom are closed in the usual manner. It is not good to have the net too deep, as the slack is washed back over the side of the hoop by the backwash of a wave. These nets are now usually made of dressed fibre.

The circumferential cord consists of a two-ply twisted cord of dressed fibre (*aho*). It is run through the marginal meshes of the open part, and is called *te ngakau o te kupenga* (the support of the net). The cord is attached to the inner side of the hoop by loops of thinner fibrous cords. These are placed 6 in. apart, and are passed through holes pierced through the inner side of the hoop (fig. 38). By this method the loops do not show on the outer side of the hoop, and are thus saved from being worn through by friction against the rocky sides of the channels. The *ngakau* cord is longer than the circumference of the net, so as to provide an extra length to tie the upper part of the hoop to the handle.

A threading-needle (*au*) forms part of the equipment. It is usually made of whalebone, about 10 in. long and fairly strong, with a blunt rounded

point. Two holes are pierced through the other end (fig. 39). Strands of dressed flax-fibre are passed through them and plaited together for a few inches with a four-ply plait (*whiri tuapuku*). It is then changed into a three-ply plait (*whiri papa*), and continued into a cord or rope about 10 ft. in length.

(*b.*) *Kupenga taki.*—This net has a larger hoop, which is kept in an oval shape by means of two cross-bars (*kaho*) tied across the handle and to the hoop on ether side (fig. 40). The previous net has the lower end somewhat



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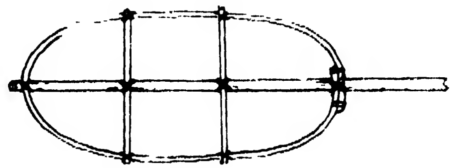

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FIG. 39.—*Au*, or threading-needle for *kehe*.
FIG. 40.—Frame with cross-bars of *kupenga taki*.

pointed, as it is used in an upright or slanting position, so that the lower end may fit into channels in the rock. The *kupenga taki* is not used in channels, but in the open water beside rocks, where it is held horizontally. Hence the difference in shape.

(*c.*) *Kupenga ruku kehe.*—This form of net is used in some parts of the Bay of Plenty in deeper water, hence the name, meaning a *kehe* net for the diving method. The hoop is again much larger than in the last, whilst the handle is as long as possible. It must be long enough to reach from the bottom of the sea to the surface.

Methods of catching Kehe.

We have indicated that the method adopted and the type of net selected depends on the seasons, the tides, and the character and disposition of the rocks. In some fishing-grounds there are definite rocky channels up which the fish come to feed. In these channels the net with the pointed lower end (*kupenga koko kehe*) is used in three ways. Each method has its name.

(1.) *Tu* (Stand).—*Tu* means "to stand," and the method takes its name from the fisherman remaining stationary at a selected spot on the channel. It is used during spring tides. The channels in the rocks are cleared and prepared. A rock in the channel covered with seaweed is selected. A stand is taken up behind it so that the seaweed conceals the net: this is especially necessary if the net has not been dyed. After the channel has been prepared it is left for three or four tides so that the fish may become accustomed to travelling up it. A track of stones may be made towards the stand, and other stones placed in position for the fisherman to stand on as the water deepens. An upright stake is often fixed to mark the spot that has been prepared.

The fisherman takes up his stand when the tide is coming in. He fits the pointed net into the channel, with the opening towards the current (*ka poua te kupenga*). Then he waits until he feels a fish bump (*tuki*) against the net, when he immediately twists the handle to bring the opening upwards and at the same time lifts the net out of the water. The threading-needle has been held by the right hand against the net-handle with a twist

of the cord round the hand, as shown in Plate 106, fig. 1. The rest of the cord hangs loose. The cord is quickly untwisted from the hand, and the needle threaded through the gills of the fish. The free end of the cord is tied to the first fish. It is dropped in the water, the needle end of the cord retwisted round the hand, and the net reset in the channel. Subsequent fish are simply threaded on the cord and dropped back into the water, the first fish tied preventing them from slipping off. If the fisherman changes to another stand, he simply trails the fish along behind him in the water. When the tide is going out the fisherman turns his net to face the current. If the fish come quickly the net may be kept down until two or three fish are in before lifting. They are then threaded (*kotui*) very quickly.

The bone needle (*au*) is long and strong, for the purpose of killing sharks if they get into the net. They are struck on the nose; and care must be taken not to let any blood stain the water, as it would attract others. Sting-rays (*whai*) sometimes get into the net. If not seen, they are readily known by their weight. The net is immediately turned upside down and lifted out of the water to allow the sting-ray to escape, as they are too difficult to deal with. Though the sting-ray is eaten, we must remember that the fisherman is in fairly deep water and some distance from the shore. The sting-ray is a breaker of nets, and the fisherman has nothing to kill it with except the bone threading-needle, which cannot prove so efficacious as in the case of the easily killed shark. As the net is removed from the water the handle is reversed, and the retirement of the sting-ray accelerated by stabbing it with the pointed end of the handle. In this method there is a certain element of excitement and danger.

Other fish, such as *kahawai* (*Arripis trutta* (Forster)), *tamure* (*Pagrosomus auratus* (Forster)), snapper, and *moki* (*Latridopsis ciliaris* (Forster)), are also caught.

(2.) *Rama* (Torch).—The pointed net is also used in the channels at night with a lighted torch, but the fisherman moves about. Torches were usually made of resinous strips of the *kahikatea* (*Podocarpus dacrydioides*; white-pine). The *kehe* are attracted towards the light, and are intercepted by the net. They are sometimes seen asleep. The net is placed in front, and the fish startled forward into it by touching with the foot.

(3.) *Kōkō* (Prodding with a Pole).—This method is the most common of all, as it can be used at any time of the year, provided, of course, there are suitable channels in the rocks. The *kōkō* method requires two men, one with the pointed net and the other with a pole about 9 ft. long. The net-bearer is the skilled fisherman who knows all the channels and the good spots for setting down his net (*hei tukunga mo te kupenga*). He is careful to avoid walking along the channel lest the fish be frightened away: he makes a detour to arrive at his proposed stand. Whilst he is placing his net in position the assistant with the pole stands away from the channel. All being ready the netter calls out "*Kōkōtia mai.*" (*Kōkō*, with long vowels, means "to prod with a pole." It is probably derived from the verb *kō*, to dig, or, rather, loosen by thrusting into the soil. It is quite a different word from *kŏkŏ*, with short vowels, which means "to scoop" or "to scrape up." Though the netter has a scoop-net to which *kŏkŏ* could apply, the process of *kōkō* in this method refers absolutely to the assistant and the process of thrusting forward with his pole in the channel to drive the fish into the net.) On the command to commence to *kōkō*, the assistant walks across to the channel and works forwards towards the netter. Besides prodding in front of him with the pole, he may strike the surface of

Waimahuru: There is a stretch of two miles of reef between this and Te Haha, all of which is good ground for *kehe*. Travelling-parties passed over Tawhiti Point whilst the reef at Waimahuru remained undisturbed. Hence the saying, *Haere tou te korero i runga o Tawhiti, takoto noa Waimahuru* (Gossip and news pass continually over Tawhiti, but Waimahuru remains undisturbed).

Te Waiwhero is in the cove to the south of Waipiro Bay.

Otama-rauiri, at the mouth of Waipiro, had no channels, and only the *hura* and *taki* methods were used here.

Mataahu, between Waipiro and Whareponga, is well known.

Wai-o-rongomai, near Whareponga, was the scene of the famous Ikakoraparua battle. The *koko* method was used before the fight.

Whareponga, near the village of that name.

Whangai-potiki, beyond Whareponga, is a large channel through the reef which was used for canoes. Here the Ngati-Porou ancestor Poroumata was killed.

Omataira, farther north of Whareponga, contains four miles of reef which was all good *kehe* ground. Sections had special names, such as Te Kehe-tuaranga, Te Ahi-kehe, &c.

Otairi to Tahere-pohue, south of Reporua, had good *kehe* grounds, where the *hura* and *taki* methods were mostly used.

Channels (Awa).

Whilst the general grounds have names, special channels in these grounds are also named. The channels are due to the geological formation, where rock-strata have been tilted and channels worn between. Up these channels we have seen that the *kehe* come on the tide to feed. Many of the channels have been improved by human agency. Not only have special stands been prepared to suit the size of the net, but the sides of the channel have been built up in places to make sure of the fish proceeding onwards. A very old channel was made by the Ngati-Ruanuku, who were dispossessed by the Ngati-Porou. The side walls were made with alternating layers of fern and stones. It was named Wananga, and still remains intact in spite of the ceaseless wear of the waves. This stability is attributed to potent incantations recited during construction. Here Rangi-rakai-kura, of Ngati-Ruanuku, was slain by Pakanui, of Ngati-Porou, during the campaign of conquest by the latter. Whilst some names are old, others are comparatively recent. Many of these *awa* belonged to particular families, and outsiders dare not trespass on them. The *kehe* is a *tapu* fish, and must not be cooked in the earth-oven at night, or they will forsake the channels.

Tupore is a famous channel at Mataahu. Amongst other fish, the very best kind of *nanua* is caught here. The feed is plentiful, and the fish get very fat—becoming, as the common phrase puts it, *he hinu katoa* (all fat).

Kauparara is near Tupore. It is also famous for *nanua*, which are at their best in March, but after that month lose condition.

Tangitu, Wetea, Manutaunoa, Tapiri, and Wananga are all channels at Mataahu. The number of named channels shows what a famous ground Mataahu was. Wananga has been mentioned above as the famous channel made by Ngati-Ruanuku.

Korouanui, Te Hoe, Kowhae-tu, Wai-whakaata, Taratara-taua, and Haowhenua are well-known *awa*.

Whangai-kuia was a large channel where the *kopipiro* and other fish were very plentiful.

Near Awanui *kehe* abound, but there are no names to the channels and grounds, owing probably to a sparser population on this part of the actual coast.

At the East Cape there are a number of named channels, of which examples are Tupo and Pokai-takataka. The *kehe* grounds here are very rich, and at one time helped to support a large population.

The Horoera district, between East Cape and Te Araroa, has the famous reef of Mataikaro. Here there are a number of channels where the *tu* method is used. Some of the channels are Te Awanui, Pararaki, Te Waipuna, Ngautahi, Te Awa-a-Koirere, Umupokipoki, and Ngareiawa. Two have modern names—Awa-o-Hare (Harry's Channel) and Awa-o-Anaru (Andrew's Channel).

The channels and rocks are useless, and hence unnamed, unless algae such as the *kohuwai* provided food to attract the *kehe*.

Season.

The season when the *kehe* are in the best condition naturally depends on the time when the best food is in abundance. The *kehe* feed on both the *parengo* and *kohuwai* seaweeds that grow abundantly on the rocks of the district. The *parengo* is best in July, and lasts till March, but the Ngati-Porou say that it seems to have shortened its period to about January. The *kohuwai* comes on when the *parengo* has died down. Its season is from March to June. It is during the *kohuwai* season that the *kehe* reach their best, being at their very best in March.

The *kehe*, however, is peculiar in that it forms good eating even when it is thin. This has led to the saying, *Tupuhi kaka ki uta, tupuhi kehe ki te moana* (A thin *kaka* on land, a thin *kehe* in the sea). The *kaka* (*Nestor meridionalis* Gray) is good eating when thin, and so is the *kehe*, though appearances may be against them. Hence the Maori say there is no restriction or closed season for the *kehe*, and the *koko* method of catching can be used throughout the year. The methods which depend upon special feeding-habits also depend upon season.

As regards the exception described in the Bay of Plenty district, where a close season is declared over the deeper fishing-grounds, it seems that this is done by chiefs to add to their prestige. The method of diving would hardly be used as an ordinary method to provide food-supplies. Thus declaring a *rahui*, or close season, over these deeper ground entails no irksome restriction on the people, and gives the chief an opportunity of exercising his *mana*, or authority. The removal provides a special function, which is as much an aquatic sports gathering as a means of providing food. At the same time it stresses the importance of the ruling family.

Miscellaneous.

The *kehe* is eaten fresh, as the flesh turns yellow if kept. The flesh is firm, and in cooking in the earth-oven it is not necessary to wrap it up in fern-leaves, as in the case of fish with a softer flesh. It is also preserved by splitting in halves (*pawhara*) and drying in the sun (*rărā*).

The old *kehe* grows very large, but are too tough to be sought after as food. They are called *katirimu*, and the Maori say they are the bull *kehe*. The word *katirimu* is thus used as a term of derision in the following extract

from a song composed for one of the competitive meetings held by the Ngati-Porou parishes some few years ago. It refers to the Horoera district, and mentions the Mataikaro reef, famous for *kehe*, crayfish, and the edible *parengo*.

Kia te kehe pohatu,
Tihei taruke,
Hinaki katirimu,
Huhuti parengo,
Kiri haunga o Mataikaro.

To the foot-crushers of rocks,
Porters of crayfish-pots,
Trappers of bull *kehe*,
Pluckers of seaweed,
With malodorous skins from Mataikaro.

The entrails of the *kehe* become very fat in the right season, and are better esteemed by the local people than the flesh of the fish. Hence, in the saying below, used as an invitation to a visitor, they make a display of hospitality and at the same time reserve the tit-bits for themselves :—

Hoatu ki te kainga,
Kotaku ika ki a koe,
Ko te ngakau ki au.

Go on to my home;
My fish will be for you
And the entrails for me.

KAHAWAI.

(2.) *Scoop-nets for* Kahawai (Arripis trutta).

The *kahawai* is a well-known fish that comes up the North Island rivers in large shoals in certain seasons. The common way of catching them is by trolling from a canoe with an unbaited wooden hook barbed with bone and inlaid with *Haliotis* shell (*paua*). From the last, the hook gets the name of *paua*. The *paua* is also used at the mouths of rivers, where it is thrown in on a long line (*piupiu*) as the tide is coming in. The current gives the hook a spin, and deludes the *kahawai* into swallowing it as a sprat. It is curious that the fish will often prefer a badly made hook with a dull piece of shell. Its vagaries in this respect are embodied in the cynical saying, *He kahawai ki te moana, he wahine ki uta* (As a *kahawai* in the sea, so is a woman on land).

Another common method of catching the *kahawai* is by means of the seine-net, which may be hauled or set in river-estuaries.

At the mouth of the Waiapu River the fish is caught in a large scoop-net. In the region under discussion it is peculiar to this particular part, but the Ven. Archdeacon H. W. Williams informed me that the method is also used at the mouth of the Wairoa River, in Hawke's Bay.

Kupenga kŏkŏ kahawai (Net for scooping-up *Kahawai*).—The word *kŏkŏ* in the name of the net is the word with the short vowel already referred to. In this case it means "to scoop up," as the person with the net does all the work and has no assistant armed with a stick to drive the fish into the net. Plate 105, fig. 1, gives a good idea of the size of the net. The net in the plate is held by Panikena Kaa, of Rangitukia, who demonstrated its use, and is mainly responsible for the information in this section. The *kupenga kŏkŏ kahawai* consists of a handle, a hoop, the net, and a circumferential cord.

The handle consists of a *manuka* pole, 14 ft. long, and with a fork at the thinner end. It needs a strong wood like *manuka* to bear the strain. The handle just below the fork is 3½ in. in circumference, and at the other end, where it is scraped down, it is 6 in. in circumference. The fork supports the hoop at one end, and at the other the handle projects 10 in. beyond the hoop. The 10 in. projection is called *te puritanga ringa* (the grasping-place), and the part within the hoop is called the *tango* (handle).

The hoop (*whiti*) is formed of two lengths of supplejack. The ends of the two pieces are passed through the fork to overlap one another for about 41 in. (fig. 41). A third piece of supplejack about 34 in. long is added to them and overlaps them for 17 in. on either side of the fork. These are securely bound together, and this end of the net is called the *rae*. The other ends of the two supplejack lengths are bent back to form a laterally compressed oval, and are crossed over the pole 10 in. from the other end. The ends are made to overlap for 17 in. on each side of the pole. The overlap is bound together and securely fastened to the pole where it crosses. Except for the curve at each end, the sides of the hoop are fairly parallel, being about 44 in. apart.

The net was usually made of dressed fibre. It is an elongated bag-net, having been made sufficiently long to go round the circumference of the hoop. It is joined at the sides and the bottom in the usual way, and is about 6½ ft. in depth. A 3 in. mesh may be used in the early part of the season, when the fish are smaller, but after November a 4½ in. mesh is preferable.

FIG. 41.—Frame of *kahawai* net.

A circumferential cord (*aho*) is threaded through the marginal meshes, and tied to the hoop at intervals of about 1 ft. This cord is the *ngakau* (support). As there is no friction against rocks, the ties are passed right round the hoop, instead of through holes as in the *kehe* net.

When not in use the slack of the net is usually knotted in three places and wrapped over the handle. In carrying the net the handle is balanced over the shoulder, as in Plate 105, fig. 1.

Method of Use.—The fish are caught as they make their way in shoals towards the mouth of the Waiapu River. They come in close to the shore and travel parallel with the beach. The shoals are easily seen, and the fishermen dash into the waves with the scoop-nets. The nets, though heavy when carried, are easily manipulated when in the water. The right hand holds the *tango*, and the left hand grasps the *puritanga ringa*. The opening of the net is directed towards the course of the fish, with the long axis horizontal. The net is then simply swept along through the shoal until a sufficient number are in. The net-opening is then turned upwards, so that the hoop is level with or above the surface of the water. The fisherman then dashes ashore, trailing the fish in the water as long as possible, and empties his catch on the beach. Many of the fish are caught

by the gills in the meshes. As soon as the net is empty he dashes back again and repeats the process. When the fish are not in big shoals only a few may be caught at a sweep. They are kept in the slack of the net near the operator until a sufficient number has been caught to justify going ashore. As the fish swim with some force, the fishermen always stand sideways to their course, so as to receive the impact of the fish passing outside the net upon the outer surface of the thigh. Though the weight of the net is lightened in the water, the dashing out and in with heavy catches of fish and a wet net make the work very strenuous. As the shoals are mostly in the smooth water just beyond the breaking waves, the fishermen when dashing out plunge head first through the larger incoming waves. Hence, to a child born with a large head, the following saying was applied: *E rahi te mahunga o tamaiti nei hei tukituki i nga ngaru o Waikaka* (The head of this child is big to break through the waves at Waikaka). Waikaka is the ocean beach to the north of the Waiapu mouth where the scoop-net is used.

At the present day the people of the village of Rangitukia are experts in this method of fishing, and are naturally proud of it. In season, when the *kahawai* are plentiful, regular field days are held on the Waikaka beach. Though the work is hard, the men enjoy the fun and competition. Sometimes a man gets out of his depth and is almost carried away by the team of live fish in his net, but the spice of danger adds to the excitement.

Food-supply.

The *kahawai* is a somewhat dry fish for eating purposes, but improves when fat. Its quantity, however, made it of some importance. In the season the local people camp on the beach. Whilst the men land the fish the women are kept busy cleaning and hanging them up. Two tripods of heavy drift timber are erected to support a cross-bar, upon which the cleaned fish are hung up to dry. This support comes under the term of *whata*. Those which cannot be eaten fresh are thus dried for future use. Inland people come down to the beach with carts, which go away heavily laden.

Season.

The *kahawai* come up the rivers in shoals, usually in pursuit of the fry of other fish. The season commences in November, but they are not usually fat until December. They are good in January, and begin to disappear in February. The usual term for a shoal of fish is *rangai*, but with *kahawai* the word *moana* is also used—as, *he moana kahawai* (a shoal of *kahawai*). In attracting attention to a shoal the closed fist or the bent elbow must be used in pointing. If the outstretched finger is used it is equivalent to a *pana* (a motion to expel). The sensitive *kahawai*, either through excellent vision or some occult power, are quick to take offence, and will depart for more courteous waters.

Influence of Environment on Fishing Methods.

Mention has been made of two other methods of catching *kahawai*—with the *paua* hook and the seine-net. Both these methods are used in the region under discussion. The Motu River is famous for *kahawai*: there the *paua* hook is used. Hicks Bay is also frequented by the *kahawai*, and there the seine-net is used. Thus, in three parts of the same cultural region, three totally distinct methods are in use. Both the Whanau-Apanui

and the Ngati-Porou recognize Pou as the tutelary guardian of fish. Until recently the first *kahawai* of the season was offered to him. Dr. Wirepa, of Te Araroa, has made some interesting observations on the reasons for these three different methods. In the Motu River the current gixes the *paua* hook the right spin as the line is drawn in. The method gives all the sport desired, and provides an ample sufficiency of food. There is no need to seek other methods. At Hicks Bay the river is sluggish and there is not sufficient current to spin the *paua* hook. The beach and estuary are clear of rocks, and have a smooth sandy bottom. The seine-net is suitable, and came into permanent use. In the Waiapu region the current is such that it casts the hook and line back on to the beach. The *paua* method was eliminated. The beach, owing to rocks in places, is unsuited for the seine-net, whether set or hauled. Thus the two ordinary methods could not be adopted. Yet it was hard to see shoals of *kahawai* passing along close to the shore without making some effort to secure them on a large scale. Shoals of whitebait were scooped up with a scoop-net. *Kahawai* were bigger, certainly—hence a larger net was required. At all events, whether from whitebait or other fish, the using of a scoop-net was tried, proved a success, and became established. Thus in this one district man adapted his procedure to suit the different local conditions; or, in other words, environment effected changes in his material culture.

WAREHOU.

(3.) *Landing-net for* Warehou (Seriolella brama *Guenther*).

The *warehou* is a salt-water fish found plentifully about Cook Strait, and along the east coast into part of the Ngati-Porou waters. It is a good-eating fish, and is caught with a baited hook on rod and line. The Ngati-Porou say that north of Gisborne the fish differs from those farther south in having a very tender mouth, which thus prevents its being lifted directly out of the water on the hook. The weight causes the lip to give way, and the fish is lost. To prevent this, a landing-net is used that is peculiar to this district.

Korapa (Landing-net).—As we have seen, the term *korapa*, whilst used generically with the two scoop-nets already described, applies particularly to the landing-net for *warehou*. Hamilton figures three in *Museum Bulletin No. 2*, page 65. He has been misinformed, however, and states in error that they were used " for fishing in rock-pools and in the long narrow rifts in the clay rocks on the east coast." This description applies to the scoop-net for *kehe*, which is also called *korapa*. The nets that he figured are landing-nets for *warehou*. The confusion has been caused by the name *korapa* being applied to both forms of net.

The *korapa* consists of a handle, hoop, and net (Plate 112, fig. 1). The handle is a short T-shaped piece of wood, which is usually carved. One limb, carved like a bird's head, is used for grasping. The cross part of the handle is curved on either side, and grooved on its outer surface to fit the hoop. The groove is continued as a hole into the actual handle, to take the ends of the hoop. The hoop is of supplejack, bent round in an oval, and lashed to the grooved part of the handle on either side. The net is a shallow bag-net. In the plate it is a rather poor one, made of string. The hoop has been run through the marginal meshes before tying to the handle.

Methods of Fishing.

The *warehou* is caught by two methods on recognized fishing-grounds :—

(1.) *Tararo.*—This method is with a hand-line about six *maro* in length. The *maro* is the distance of a full span of the arms. Roughly, it is usually regarded as about a fathom. The fish does not keep to the bottom, hence the shortness of the line and the light sinker used with it.

(2.) *Tihengi* (Rod-fishing).—With the same length of line, a rod, called a *tautara,* is used. The rod is made from a *toatoa* sapling about 8 ft. to 9 ft. long. The *toatoa* growing on the hills are considered best for the purpose, as they are *kakara* (sweet-smelling). Sometimes a short carved piece of wood, about 7 in. long, is lashed to the end of the rod. The carving is in the form of a head, and contains holes, to which loops may be attached. One is figured by Hamilton in *Dominion Museum Bulletin No. 2*, fig. 47. To the end of the rod, or one of the holes in the carving, is attached a loop carrying a number of threaded shells of the univalve called *ataata* (*Turbo smaragdus* Martyn). Through the loop the 6-fathom line passes. The baited line is thrown out, and the proximal end of the rod attached to one of the thwarts of the canoe. A man may have two or more rods out. When the fish takes the baited hook the pulling on the line causes the shells to make a noise, which attracts attention. Part of the equipment is a *rou*—a rod slightly longer than the *tautara* and hooked at one end. The *rou* is also of *toatoa,* and is prepared by tying the top of a thin growing sapling into a loose overhand knot. When it grows to the right size it is cut down and the knot trimmed into a hook, which will not straighten out. When the shells jingle, the fisherman reaches out with the *rou,* hooks in the line from beyond the edge of the rod, and brings it to his hand.

Since the above was written the writer had the privilege of accompanying Mr. George Ryland on to the *warehou* fishing-grounds off Tokomaru Bay. Some extra details were noted. The appropriate length of line was knotted near the end of the rod with an overhand knot, and the proximal end brought along the rod for 3 ft. or 4 ft., when another overhand knot was made and another length of fishing-line freed. Thus to each rod there were two fishing-lines with their own hooks and sinkers. The proximal end of the rod was fixed to a thwart, and the fisherman also used a hand-line. The *tararo* and *tihengi* methods were carried on at the same time. The object was to have as many lines out as possible in the restricted space available. Each fisherman sitting on a thwart, instead of being restricted to one line, had three lines, which were well spaced outwards to prevent their becoming entangled. Instead of shells, a tin match-box containing leaden shot was tied to the end of the rod. When the fish pulled on the baited hooks the sound made by the shot in the match-box attracted immediate attention.

Use of the Landing-net.

When the fish is hooked the line is hauled in, and when it is close to the canoe it is played with one hand whilst the other slips the landing-net into the water. The fish is met with the net, but if it pulls away it is played. Once in the landing-net there is no hurry in lifting it into the canoe. The fish struggles strongly at first, and it is allowed to exhaust itself before being lifted in. If there is another fishing-canoe near at hand, the correct thing is to jam the fish against the outside of the canoe with the net and let its flappings be heard by the rival fishermen, who are further annoyed by the exultant yells of their successful neighbours.

Bait.

The best bait is the flesh of the crayfish.

Omens.

Dreams were regarded as omens. The lucky omens were to dream of cooked food, old torn garments, being bespattered with mud and dirt, or embracing a woman. As the luck indicated by a dream was personal, the dreamer kept it to himself. The luck could be taken by any one who put his arm round the dreamer. The dreamer would then catch about two fish whilst the other obtained a big catch. The dreamer, therefore, besides concealing his dream, would keep away from too close contact with any one, lest any demonstration of affection rob him of his luck. This action often defeated its purpose, for non-dreamers were on the lookout for any one who avoided them. The dreamer, however, could save his luck by immediately striking with his open hand the person who embraced him and saying, "*E kore taku moe e riro i a koe*" ("My dream cannot be taken by you"). On the fishing-ground the lucky dreamer caught all the fish whilst the others looked vainly on.

Cooking.

The fish had to be cooked in the earth-oven (*tao*) and not broiled or grilled until the season was well advanced. Immediate grilling on return to the shore was termed *taiki*, and caused the fish to leave the fishing-ground.

Season.

This varied, on different grounds, from April to July.

Fishing-grounds.

Te Puna was a famous ground near Akuaku, between Waipiro and Wharepounga. It opened in April. The term for opening a fishing-ground is *takiri:* thus, *Ka takiritia Te Puna i a Aperira* (Te Puna will be opened in April). The *mana,* or authority, over this ground was exercised by the chief of the Whanau-o-Te-Haemata subtribe. The first fish had to be eaten by the chief of that family, who at present is Tuta Ngarimu.

Te Poroporo ground is near Waipiro, close to the point. There large fish are caught.

Puakato, near Waimahuru, has large fish, and opens as late as July. The *mana* belongs to the Whanau-a-Rakairoa subtribe. To that tribe belongs Renata Tamepo, who supplied these notes. The ground is mentioned in a lament composed by Riria Turiwhewhe for Te Rakahurimai, who, with a boat's crew, was blown out to sea by a *parera* wind and drowned.

E au kuware kihei rawa i puritia
Tukua kia haere kia tae te koronga
Tera Puakato ka rewa kei runga,
Kei tua koutou e aroha nei au-ee

Ah! ignorant I, who did not detain,
But allowed their wish to seek its end!
There Puakato rises above the waves;
Beyond lie ye for whom I grieve—ah me!

B. Bag-nets.

Bag-nets are attached to circular hoops, and depend upon bait for attracting fish within the area of the hoop. The presence of the fish being known by touch or sight, the net is drawn up vertically and, as the tendency of fish is to sound or dive downwards when startled, they are easily secured within the net. In this section there are three kinds of nets, for securing (1) crayfish, (2) *tangahangaha*, and (3) *maomao*.

Crayfish.

(1.) *Bag-net for Crayfish* (Pouraka).

Crayfish are very plentiful all along the East Coast and Bay of Plenty area. There are four methods of securing them. The commonest is by diving. A simple method is with the *matire*, a rod with a number of strands of flax looped over one end. In the midst of the strands is a bait of *paua* (*Haliotis*). The rod is thrust down into rocky crevices. The crayfish, attracted by the bait, gets its legs tangled in the strands and is drawn to the surface. A third method is by baited crayfish-pots made of thin *manuka* rods. These traps are called *taruke*, and are set on the sea-bottom, whilst a long rope with wooden floats marks the spot.

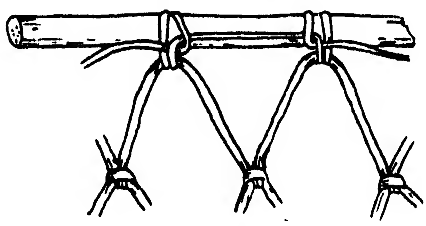


Fig. 42.—Attachment of *pouraka* net to hoop.

The fourth method is by means of the bag-net termed *pouraka*. In the East Coast - Bay of Plenty area *pouraka* refers solely to this kind of trap. In Lake Taupo a *pouraka* is a netted trap, set like a *taruke*, and used for catching *kokopu* (*Galaxias brevipinnis*). At Maketu and on the Waikato coast the *pouraka* is similar in make to that of Lake Taupo, but is used to catch *aua* (*Agonostoma forsteri*). The crayfish-*pouraka* consists of a net, hoop, handle, sinkers, bait-support, and line (Plate 107, fig. 1).

The net is made of flaxen strips. Thirty-one meshes are put on the supporting-strand, by any one of the three direct mesh-commencements. The thirty-second mesh is added when the sides are closed. The depth is carried down to ten rows of meshes, additional meshes being added. The sides and bottom are closed as already described.

The hoop for the mouth of the net (*whiti*, or *potaka*) is of supplejack. With the Ngati-Porou the supplejack is threaded through the marginal meshes, the ends overlapped, and lashed together. Roughly, the hoop was 36 in. or more in diameter. With the Whanau-Apanui the bag-net is attached to the hoop by a chain-knot of fibre-cord, which is looped twice round the hoop and each circumferential mesh, as shown in fig. 42.

The handle is made of split supplejack, which forms an arch over the hoop. The ends are attached to opposite points of the hoop by doubling

the ends round the hoop with a 6 in. or 7 in. overlap and lashing together as in fig. 43. Another strip of supplejack may be attached in a similar manner at right angles to the first, and an additional lashing made where the two handles cross at the top of the arch. This arched handle is called a *pewa*.

In some nets I saw at Opape, in the Bay of Plenty, a single handle was used, but these were stayed with two sets of a two-ply twisted cord of undressed flax, as shown in fig. 44. The handle also had two cords of a similar nature stretched across from side to side at the levels of the two sets of side stays, as shown in fig. 43. These are tied to the handle below the side stays so as to prevent their slipping up on the handle. In this last type the bait is attached to the middle of the lower cord. In the double handle there is no need for these two cords. A special cord for the bait is therefore stretched across the circumference of the hoop from the bases of one of the handles. The bait-cord is called the *pae mounu*. In some cases a special bait-rest is made by tying a short piece of stick at right angles to the middle of the bait-cord to form a cross. A strip of flax about ½ in. wide is then wrapped successively round each arm of the cross so as to overlap, as in a fly-flap.* To this a piece of thin flax is attached to tie on the bait, which is laid on the lozenge-shaped bait-rest. This bait-tie is called the *tau-mounu*. Sinkers (*punga*) of stone are attached on the outer side of the circumferential hoop at the handle-junctions,

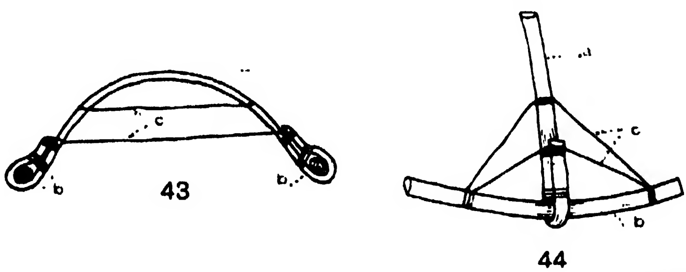


FIG. 43.—*Pouraka* handle: *a*, handle; *b*, cross-section of hoop; *c*, handle-stays.
FIG. 44.—*Pouraka* handle: *a*, handle; *b*, hoop; *c*, side stays.

care being taken to select stones of even weight so as to maintain the balance. In these days a piece of cloth is often wrapped round the stones to prevent their slipping. In ancient days grooves were chipped on the stones, or they were enclosed in a small net to serve a similar purpose. A line or fine rope of sufficient length was attached to the handle or the crossing of the two.

An ingenious thought was the attachment of a thin strip of flax from the bait-rest to the lower end of the line where it was attached to the handle. When the baited trap rested on the bottom of the sea, the tugging of the crayfish at the bait was clearly transmitted along this cord to the line and the fisherman above. It was therefore called "*te tau whakarongo*"—the feeling-string.

Method of Use.—The *pouraka* is baited usually with *paua* (*Haliotis*), or any kind of fish. In these days meat may be used. In the night-time

* TE RANGI HIROA, Maori Plaited Basketry and Plaitwork, *Trans. N.Z. Inst.*, vol. 55, p. 356, 1924.

the nets may be set in the shallow water near the reefs, at low water, or just when the tide is coming in. When baited the net is simply lowered into the water at the selected spot, and the sinkers take it to the bottom. If the line is held, the pulling of a crayfish at the bait is transmitted up the feeling-string to the line, and distinctly felt. On hauling up, the crayfish drop down into the net. It is usual, however, to set a number of nets and tie the ropes to rocks or points on the reef. When the last is set the fisherman starts at the first and lifts them up. They are reset when the contents are removed. By the time he has completed his task it is time to start on his round again. Half a dozen nets is a convenient number to keep one man employed.

In deep water the nets may be set in the daytime. A raft (*mokihi*) made of the light *houama* (*Entelea arborescens*) is used. Floats (*poito*) of the same wood are tied with a clove hitch to the end of the rope when the net reaches the bottom. A number are set, and the fisherman paddles round on the raft, picking them up in turn. When crayfish are plentiful, ten or twelve are caught in one net at a haul.

Season.

Crayfish are caught all the year round, being at their best in September and October, but especially in September, when the *kowhai* (*Edwardsia tetraptera*) is in bloom. *Koura* are not put in fresh water to render them soft (*mara*) until the blooms are off the *kowhai*. If it is done, the crayfish becomes small (*pakupaku*), thin (*tupuhi*), and *rerewai*. *Rerewai* means that there is nothing inside the cephalothorax (*papa*) but froth (*pohuka*). After October the crayfish sheds its shell. This process of ecdysis is termed *maunu* (to become loosened or cast off). The same term is applied to birds when moulting, as in *parera maunu* (a moulting duck). The soft crayfish is called a *koura maunu*. They are very fat, and esteemed best of all *koura*. Hence November is looked upon as the best month of the season.

Crayfish-holes (Rua Koura).

When the crayfish are shedding their shells they collect in large numbers in certain holes between the rocks. These spots are called *rua maunu* (shell-shedding holes), or simply *rua koura*. A knowledge of their location is very important, and they are named. Such are Kaitangata, Tara-o-kaikore, and Oruamariu, at and near Horoera. Others are Te Awa-tapae and Hangai-koroua. Te Wharau-o-Ngati-Porou and Okahu are two famous *rua koura* at Mataaho. The former faces south and the latter north. Tangitu and Te Poti are also in this neighbourhood. In the season boats are taken to them and the *koura* loaded in sacks. In feeling for them, the old shells are removed first, to get at the fish which are below.

Grounds for setting Traps (Tukutukunga Taruke).

Though these grounds are for setting *taruke* traps, the *pouraka* is used on them in the daytime. They are situated out in the deeper water. These grounds, like fishing-grounds, are picked up from certain land-marks. Two cross-bearings are obtained by certain objects being got into line: the bearings were referred to as *nga rarangi* (the lines). Good grounds were named: such are Te Poho-o-Whakarara, at Mataikaro; Tunga-o-Hurumaнu, Taka-koau, Te Rua, Tunga-o-Tope, Ngawhakararangi, and Tokatutahi, all in the vicinity of Horoera.

Names of Crayfish.

Different names are given to crayfish, but they seem to refer more to various sizes. Thus the smallest ones are called *weta* · the ordinary larger size, *matapuku;* and the very largest, *pawharu*. *Pawharu* are caught only in deep water. They are often covered with shells, and are considered the best for eating. A dark-coloured crayfish is called *matapara.*

New Zealand marine crayfish* were first assigned to the genus *Palinurus.* The common crayfish was described as *Palinurus edwardsii.* The generic name now stands as *Jasus*, and of the two species inhabiting these waters the common market crayfish is *Jasus lalandii,* and the rarer one *Jasus hugelii.* Whether the Maori names above represent different sizes of *Jasus lalandii*, or whether the *matapara* and the *pawharu* represent *Jasus hugelii,* I am unable to say at present.

Parts of the Crayfish.

The antennae are called *puihi.* The first large pair of legs are called the *konui.* The same word is applied to the human thumb or big toe. The other four pairs are the *waewae* (legs). The abdomen (commonly called the "tail") is the *hiku*—also meaning "tail." The cephalothorax is divided into two: the upper part with the carapace is called the *papa,* and the lower part with the sternum is the *tuke.*

Diving for Crayfish.

The crayfish frequent the clefts between the rocks in parts that are easily accessible at low tide. These are obtained by submerging or diving. A plaited basket with three pairs of handles is fastened round the waist by a strong strip of flax tied to the outer pairs of handles. This type of basket is called a *kawhiu,* and is also used for gathering shell-fish. The fisher feels down the crevices with the foot for the *puihi* of the crayfish, or any other part. If the water is very shallow the crayfish is reached by the arm; if beyond reach, the fisher simply submerges under the water sufficiently to reach the fish. If deeper still, the head has to go down and the feet up in the process of diving. In grasping the *koura,* it is seized by the *papa* (carapace): it then comes up easily. It is usual, also, to turn the crayfish with its legs upwards immediately, to render it helpless. If the fish is caught by the *konui* it is difficult to get it up: the leg usually breaks off. The right thing is to break the other one off as well and so render extraction more easy. Though this pair of legs is not furnished with chelae, or nippers, one has to be careful, as they can inflict a very nasty scratch. Women usually do the diving. In the old days, when a certain definite procedure was still observed, if a woman broke off a *konui* she always dived back to remove it: otherwise crayfish never returned to the hole. In the *kawhiu* basket the middle untied pair of handles are pulled apart to admit the catch. Experts emerge from a dive with a crayfish in each hand, and some are said to come up with a third crayfish in the mouth, where presumably it has been transferred by hand. In these degenerate days an old sock is often used as a glove to protect the hand from the sharp spines.

* G. ARCHEY, The Marine Crayfish of New Zealand, *Trans. N.Z. Inst.*, vol. 48, p. 396, 1915.

Cooking and Preserving.

Crayfish cooked in a *hangi* (earth-oven) have a better flavour than if boiled. A great delicacy with the Maori is *koura mara.* This is prepared by soaking the crayfish in fresh water for about three days if the water is warm, and four or five if it is colder. The test is the loosening of the shell. When it comes away easily it is termed *mahiti.* People used to crayfish will then eat them raw and enjoy them : the smell is worse than the taste. When thoroughly *mara* the fish separates into three parts—the *tuke*, *papa*, and *hiku*. The flesh of the legs easily separates and comes away with the *tuke.* The flesh is placed on a wooden platform or support and left to dry for a day. Two *tuke* are placed together (*karapiti*), beaten or pounded to stick together, and exposed for another day. They are again beaten, cooked in an earth-oven, and dried. When dry they are packed in baskets, and will keep for a year. The other parts are dealt with in a similar manner. The *papa* part is usually consumed by the family, but the *tuke* and *hiku* parts are kept in the storehouse for occasions. Crayfish preserved in this way, whilst very palatable, create a great thirst. In the historic attack on the fort of Pakaurangi the garrison were given a present of preserved crayfish beforehand. The fort was then invested and the water-supply cut off. The inmates were so crazy with thirst that some of them broke through and sprang into the water, covered with as many garments as they could carry. A few regained the fort, and the unfortunate inmates squeezed precious drops out of the soaked garments. Hence the battle was called *Pueru Maku* (The Battle of the Wet Garments). The incident is referred to in song :—

He koura te kai i tahuri ai Pakaurangi.

Crayfish was the food through which Pakaurangi fell.

TANGAHANGAHA.

(2.) *Bag-net for Tangahangaha* (Tutoko Tangahangaha).

The *tangahangaha* (*Pseudolabrus pittensis*, banded parrot-fish) is one of the smaller fish found about the rocks and reefs. Though the net to be described is usually associated with it by name, any of the other rock-fish are equally welcome.

The *tutoko* is made on the same principle as the *pouraka*, but it differs in having a long rigid wooden handle. The handle thus takes the place of the line, and sinkers are rendered unnecessary. It consists of a net, hoop, handle, and bait-string (Plate 107, fig. 2).

The net is a bag-net made like the *pouraka*. In the net figured the closed-loop commencement was used, with thirty-two loops. The net was continued down for ten meshes in depth, and no additional meshes were added. The side and bottom were closed in the usual way. In this case the bottom was the last row of meshes made. The hoop was made of split supplejack, 49 in. in actual circumference. The length of supplejack is thus a few inches longer to allow for overlap. In the net, the supporting-strand is left in position and adjusted to the circumference of the hoop, or a stronger strand is put through the closed loops in its place. This circumferential cord is tied to the hoop at regular intervals with overhand knots.

The handle consists of a *manuka* rod about 10 ft. long, with two long, thin branches forming a fork at one end. The branches are cut off level and tied to each side of the hoop, as clearly shown in the plate.

The bait-cord consists of a strip of flax tied across the hoop between the two limbs of the handle. Its middle carries a *pae mounu* (bait-support), as in the crayfish-net. The strip of flax attached to the bait-support, and temporarily attached to the left limb of the handle in the plate, is the *tau mounu*, or bait-tie. From the bait-support to the bifurcation of the handle stretches another strip of flax, the *tau whakarongo*, or feeling-line, to convey messages to the person at the end of the handle.

The difference in shape between the *pouraka* and the *tutoko* nets will be noticed. Though they started with the same number of loops or meshes, in the *pouraka* additional meshes were added, whilst the longer hoop has stretched the upper meshes. The net has thus an inverted-cone appearance. In the *tutoko* no additional meshes were added, but the hoop has stretched the upper meshes whilst the bottom has been flattened out by the bottom join. This gives the net a shape somewhat like an hour-glass.

Method of Use.—The net is baited with crayfish, or any kind of fish or meat, and the bait securely tied to the bait-rest by means of the bait-tie. It is used off the rocks, and by means of the long rigid handle can be thrust anywhere, either to the bottom or to any intermediate position.

The net is very successful in taking smaller fish which often cannot be taken with a line. Even fairly large fish, such as snapper and *moki*, may be caught in it. It is easy to make, and would form a useful net for seaside campers near rocks and reefs.

MAOMAO.

(3.) *Bag-net for* Maomao (Matarau).

The *maomao* (*Scorpis violaceus* Hutton) is a deep-sea fish that travels in shoals. It frequents certain grounds in season. It was for fishing from a canoe on the grounds that the large bag-net was devised.

The net is called a *matarau* by the Ngati-Porou, from *mata* (mesh) and *rau* (a hundred, or many). The Whanau-Apanui and the Ngati-Awa call it *wahanui* (large mouth), from the size of the opening. I understand that the Ngati-Kahungunu, of Hawke's Bay, call it *tawiri* or *tawaru*. The *matarau* consists of a net, hoops, and an arrangement of cords and lines to suspend the net and carry the bait. A sinker and a strong rod are also used. (Plate 108, fig. 2.)

The net part consists of two distinct nets. They are made of prepared flax-fibre twisted into two-ply cords. The upper net is made about 36 ft. long and 5 ft. deep. No additional meshes are introduced. When completed the sides are joined together to make a cylinder about 12 ft. in diameter. The lower net is started with the closed-loop commencement, with fewer meshes than the first net. This is rapidly increased by additional meshes until, when about the same depth as the first, it has exactly the same number of meshes. The sides are now joined to form a cone- or funnel-shaped net. It is turned base upwards, and joined to the lower circumference of the first net by running a strong cord through the marginal meshes of each, as in fig. 45. The cord, which is called the *ngakau*, is tied together at its two ends. Another strong cord is now passed through the closed loop at the bottom of the second net, drawn taut, and tied to close the opening.

There are two hoops in this net. The upper, which forms the opening, is composed of two or three supplejacks twisted together, and having a diameter of 12 ft. to correspond with the upper net. The upper margin of

the first net is securely lashed to the hoop with a continuous cord. A second hoop of a single supplejack is tied round at the junction of the two nets to assist in keeping the net spread out. The two nets and the hoop show up well in Plate 108, fig. 2. The owner, Hohepa Piri, is shown on the left of the picture.

The complicated arrangement of lines is seen in Plate 108, fig. 1. These lines of dressed fibre are spliced to a central cord ending in a loop to which a line and rod are attached during fishing operations. The upper set of radiating lines are eight in number. These are suspension lines, and are called *tau popoia*. The outer ends are attached by clove hitches to the upper hoop at regular intervals—*i.e.*, 4½ ft. Below them is a set of four radiating lines which are tied to the hoop alongside four alternate suspension lines. They are the bait-lines (*tau mounu*). To each of these is attached a number of fine cords throughout their length. They are the bait-ties (*taka mounu*). A short length of cord connects the centres of the two sets of radiating lines. This seems to keep the system of lines together, besides suspending the bait-lines. From the fact that it also transmits the pulling of the fish on the bait to the line above, it is called the *tau whakarongo* (the feeling-line). It is named on principle; for the fish are observed by sight and not by touch.

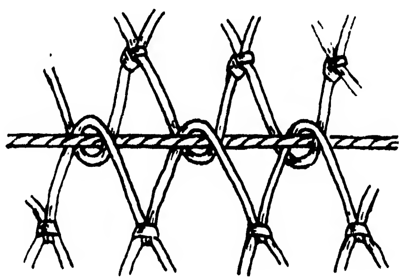


Fig. 45.—The *ngakau* cord joining the free margins of two nets.

The whole system of lines is neatly spliced together, and when the net is not in use the lines are removed and folded up in one piece. This method obviates time and trouble when the net is being assembled. Before going out to the fishing-grounds the net is put together and suspended from a spar. The suspension and bait-lines are then tightened or loosened until the net hangs true.

A stone, or *punga*, is tied to the bottom of the net to act as a sinker, as shown in Plate 108, fig. 2.

Method of Use.—When the net is assembled the upper and lower hoops are placed together. The circle is flattened by bringing two opposite points together, and then, by a kind of figure-of-eight movement, the hoop is twisted on itself in the middle and doubled over to form a double hoop occupying half the size: this is for ease of transport on the canoe. When the fishing-ground is reached the net is untwisted and the four lines baited with the tail-part (abdomen) of crayfish: this is the proper bait. Some idea of the number of bait-ties on the lines may be gained from the fact that it takes a large sack and a half of crayfish to completely bait the lines. The net is put over the side, with a line attached to the loop above the supporting-lines at one end and to a slanting rod at the other. The net

is lowered below the surface, and the crushed parts of the cephalothorax of the crayfish thrown out on the surface to attract the fish. This loose bait is called *poapoa*, or *taruru*. *Maomao* swim fairly close to the surface. When a shoal is attracted to the surface, the fish darting round the loose bait fairly make the sea foam. The tails, dorsal fins, and mouths of the fish come up above the surface of the water. The upper hoop of the net is kept about 3 ft. or 4 ft. below the surface. The fish soon find the bait-lines, and when sufficient are over the net it is raised. The startled *maomao* dart downwards—never upwards or sideways. They remain in the region of the lower net. The hoop is again lowered to allow more fish to get to the bait-lines. When it is judged that a sufficient catch is in the lower net the hoop is raised out of the water and the sides of the net drawn in by hand and gradually raised until all the fish are concentrated in the lower part of the net. This part is then lifted into the canoe. The whole net is never raised out of the water by means of the rod, as it would not only be too awkward from the depth of the net, but the weight of the fish would break the supporting-lines. The cord at the bottom of the net is unfastened and the fish poured out into the canoe. The smaller fish are entangled in the meshes of the net: these are called *papapa*. The fish which are too large to be enmeshed are called *kiwi*. Large numbers are caught—as many as from seven hundred to two thousand. Seven hundred is looked upon as a poor catch, and the following phrase expresses this: *Kaore i mate te ika* (There was a poor killing of fish). The fish are so ravenous that they will even struggle over the hoop when it is level with the surface to get at the bait. When a shoal appears, the part of the hoop near the canoe is often kept out of the water whilst the outer part is raised and lowered by hand.

Status of Maomao.

Amongst the older people the two fish of consequence in this area were the *maomao* and the *moki* (*Latris ciliaris*). According to some, both these fish were obtained by Pou from Hawaiki. They are referred to as *nga potiki a Rehua* (the children of Rehua). When the signs of the season were seen in the heavens the phrase was used, *Kua tata nga po o nga potiki a Rehua* (The nights of the children of Rehua are drawing near).

Season.

The season for *maomao* begins towards the end of January, lasts through February and March, and ends in the early part of April.

Fishing-grounds.

The *matarau* was only used on definitely-located fishing-grounds. Between Gisborne and Hicks Bay there is only one fishing-ground of any importance: this is off Waipiro Bay. Farther round the coast to the north and west the fishing is much better. A very famous *maomao* ground is situated off Lotin Point. Hohepa Piri, owner of the net figured, annually travelled up from Te Araroa to Lotin Point for the fishing. The catch was cooked and brought home for distribution amongst his friends and relatives. He had just returned when these notes were made, and we had the opportunity of partaking of some of the last-cooked *maomao* of the season's catch. Another famous ground was at Motu-kiore, off Te Kaha.

Cooking.

The best way of cooking *maomao* is by grilling. A fire is lighted on the fine gravel beach. When the gravel beneath the fire becomes heated the wood and embers are swept aside. Sticks are laid parallel over the heated gravel and pressed down. The fish are laid across the sticks, and the heat of the hot gravel cooks them. The Maori say that the fish are so fat that they cook in their own fat. The fish are so rich that it takes a good trencherman to eat two whole ones. When cooked and dried they keep for some time.

Habits.

The *maomao* moves in shoals. The Maori naturalists held the opinion that when they were directing their course in a certain direction they were never turned back. Tamatea, defeated in battle in the region of Doubtless Bay in the north, set off with his fleet for the south. On rounding Nukutaurua Point he met the fleet of Kauri coming up with reinforcements. The latter urged him to return; but Tamatea replied, "*He rangai maomao ka taka i tua o Nukutaurua e kore a muri e hoki ia*" (A shoal of *maomao* that rounds Nukutaurua Point never goes back).

C. Set Trap-nets.

Set trap-nets differ from scoop-nets in being left in a set position, and depending for their catch on the current of stream or tide, the seasonal movement of fish, or human beaters. They differ from bag-nets in being unbaited. In the area under consideration there are four varieties of nets, of which three are used in fresh water and one in salt water. The one used in salt water is the seventh method for catching *kehe*, so it will be dealt with first.

KEHE.

(1.) *Set-net for* Kehe (Haua, *or* Hinaki Kehe).

(Plate 114.)

This net is called *haua* by the Whanau-Apanui, and *hinaki kehe* by the Ngati-Porou. The word *hinaki* properly belongs to eel-traps made of stiff material. It seems to be used, however, for all traps which are set horizontally, and thus have the entrance facing sideways like the door of a house. Thus traps made of rushes to catch *koaro* in Lake Roto Aira are called *hinaki*. Two traps in this section, made of flax netting, but used in the horizontal position, are called *hinaki*. The traps with the opening facing upwards, such as the rigid *taruke* and the netted *pouraka*, for *kokopu* or *aua*, are never called *hinaki*.

The *hinaki kehe* consists of a framework of poles and hoops and two nets stretched over them. The framework consists of six *manuka* poles, of which four are from 5 ft. to 6 ft. long and two are 1 ft. longer. Sometimes *kohekohe* poles are used. These poles are tied together at the thin ends, and at the other ends attached at regular intervals round a hoop. The diameter of the outer hoop varies. The one I saw at Te Kaha was oval, with the diameter 38 in. by 48 in. The rods and hoop thus form a long cone. Two other hoops are fitted into the cone, one being 20 in. from the outer and the other about 18 in. from the second. The rods are securely tied to the hoops, and the framework rendered firm. The hoops are made of supplejack. In some traps there may be four hoops. The two longer

rods are placed at the lower part of the framework, and project 1 ft. beyond the outer hoop.

The net part consists of two funnel-shaped nets. The first net is commenced with ten closed loops, and additional meshes are added gradually until there are forty meshes to a row. By this time the depth of the net should be from the outstretched finger-tips to the point of the opposite shoulder. The sides are joined, and both ends are left open. The second net is commenced with twelve loops, and increased also to forty meshes per row. The depth is from the finger-tips to the sternum.

The small end of the second net forms the trap. A two-ply twisted cord of flaxen strips is passed through four or five of the lower loops of the smaller opening and tied on either side. This cord is drawn fairly taut across the horizontal diameter of the third hoop and the ends tied. It gives the counter-pull against the base end of the net, as it is turned over the outer hoop and stretched back over the framework as far as it will go, evenly all round the circumference. The middle part of the two-ply cord is the part that the threaded meshes of the smaller end can occupy when the base is evenly stretched. The pull coming evenly from all the radii of the funnel helps to maintain them there. Thus the cord, besides providing counter-pull in stretching the net, also serves to assist in keeping the smaller opening in the middle axis of the framework. The outer part of the net stretches back on the framework for 12 in. or more.

The other net is now drawn over the small end of the frame. Its base or larger opening is drawn up to the base of the other net, and they are joined together by running a cord through the marginal meshes of each, as in the case of the two nets in the *matarau* for the *maomao* fish. The net is then pulled back to tighten it. A cord is passed through the loops of the small end, and tied round the small end of the framework about 12 in. from the end. Owing to the overlap of the frame-rods with the necessary lashing, it is at this spot that the interstices between the rods are wide enough to need covering by the net. Thus the outer surface of the framework is completely covered by netting, and a funnel projects inwards from the outer hoop. The small internal end of the funnel occupies a central position upon the cord fixing the lower meshes. The upper meshes of the opening hang loose, and, whilst they offer no obstruction to fish entering, their collapsed condition renders return more difficult. It is found that the loose meshes act better than a hoop. The funnel is called the *puwhatero* (see fig. 46).

Two hoops are passed round outside the net in the position of the outer and second hoops of the framework. These are to protect the net from wear-and-tear on the rocks. In general principle the net resembles the eel-trap, or *hinaki*. Any seeming inconsistencies between the distances given will be found to disappear when the nets are stretched, the small end of the framework well lashed together, and the cord supporting the opening readjusted to suit the stretching of the nets.

A typical *haua* is shown in Plate 114: this net was specially made for this article by Te Pirimi Tautuhi, of Te Kaha.

Method of Use.—A place is selected at low water where *parengo* or *kohuwai* seaweeds are plentiful. The place is cleared to suit the net, and stones may be arranged to form a *pa*, or race, towards the net. A piece of wood (*rakau kurupae*) is laid down to make a firm foundation for the net. Another piece of wood is lashed across the projecting ends of the two lower rods of the framework. Stones are placed on these ends to keep the net

down. The thin end is also weighted down, and stones are placed at the sides. In addition, ropes are tied from the front and back to rocks to keep the trap in position when the tide rises and falls. The trap is set facing the shore or a large pool near the shore: it is fixed in position when the tide is out. The catch is made when the tide is going out. Fish returning down the channel and following the current pass into the trap and cannot get out. Other fish, such as snapper and *moki*, are caught as well as *kehe*. Sometimes thirty or forty fish are caught. Occasionally a shark gets into the net and knocks it about. Shags have entered the net whilst diving down the channel after fish, and have been found drowned.

The fish are collected after the tide has gone out. The Ngati-Porou remove the fish from the net by untying the cord threaded through the bases of the two nets. The Whanau-Apanui untie the loop round the small end of the net tied to the apex of the framework. When this latter opening is loosened and stretched there is ample room for the exit of the fish.

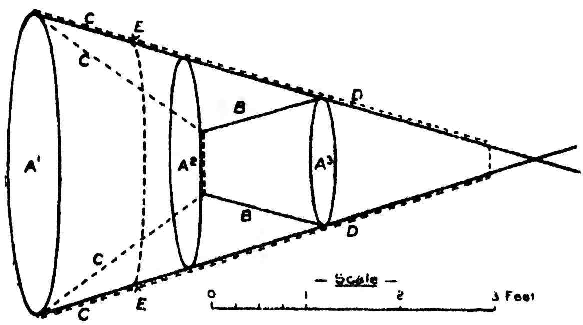


FIG. 46.—*Hinaki kehe:* diagrammatic sketch. A^1, outer hoop, 38 in. diameter. A^2, A^3, second and third hoops, 20 in. and 38 in. respectively from outer hoop. B, cord spreading small opening of trap-net and holding it in centre. C, trap-net (length—from finger-tips to sternum, 39 in.; side of cone, 26 in.; outer overlap, 13 in.). D, outer net (length from finger-tips to opposite shoulder, 47 in.). E, place of overlap of trap-net and outer net.

For fresh-water fish in the rivers and streams there are three traps where netting is used. There was a scoop-net used in catching whitebait, but, owing to the fine mesh required, true netting was not used. This special scoop-net, called a *kaka*, was made from rushes (*wiwi*), or strips of green flax. These were placed like the warps in weaving, and kept together by spaced rows of single-pair twining, as in rain-capes. A rectangular piece was completed, doubled over, the sides sewn together, and a hoop fitted into the open part. A handle was then attached. The use of scrim or mosquito-netting has led to this type of net being abandoned.

GRAYLING..

(2.) *Net for Grayling* (Kupenga Upokororo).

The *upokororo* (*Prototroctes oxyrhyncus* Guenther), New Zealand grayling, was once very plentiful in the upper branches of the Waipu, Awatere, Wharekahika, and other streams. The fish travels in shoals, and frequents rivers with a shingly bottom. Nets were set in the rapids in prepared sites and the fish driven into them.

The net is made like the scoop-net used in the *hura* and *tu* methods of catching *kehe*, but the handle is short, and used to fix the net in a stationary position. The technique of the net is like that of the bag-net described, but is made longer and deeper. The hoop consists of supplejack, which is kept in a flattened oval shape by means of three cross-bars, or *kaho* (fig. 47). The handle (*tango*) projects for about 2 ft. on either side of the long axis of the hoop. It is securely lashed to the hoop and the cross-bars.

Method of Use.—The fish usually feed at night on the fresh-water algae growing on the river-boulders. In the daytime they rest in the deep pools. Sometimes their silvery sheen may be seen gleaming in the daytime as they turn about round the boulders on the rapids. Their whereabouts may be detected by examining the rocks for marks of their feeding: the weeds are found to be eaten down, and marks of their teeth may even be found on the softer sedimentary rocks. Having been approximately located, a place is prepared on the rapids for the net. Rapids are chosen not only for the shallow depth, but also that the current may be utilized. Stones are arranged and built up to form a V-shaped race, at the point of which the net is set. The handle at each side is supported to keep it securely in position. The wings of the race may be run well out: these

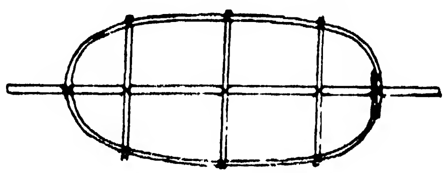


FIG. 47.—Framework of net for catching grayling.

stone wings are called *koumu*. It is not necessary to make a close wall. Large stones here and there in line directs the course of the current and the fish towards the net. Three or more nets may be set on the rapids (*taheke*), according to the width of the stream.

It is better to have several men to drive the fish into the nets. The nets being set, the beaters go up-stream above the deep pools where the fish are suspected to be asleep. The beaters are armed with poles, to one end of which a bunch of fern or leafy branch is attached: these are called *raupoto*. With them they beat down-stream, swimming in the deep pools, thrusting with the poles and beating the surface of the water to startle the fish down-stream. They follow them up over the shallow water of the rapids, and drive them into the nets in shoals. Sometimes the fish attempt to turn back from the rapids, and many are killed with the poles. Large numbers are caught in the nets, the fish becoming enmeshed. Where the shoals are large many fish have to be allowed to escape, as the nets become full and may break. On occasions, in more recent times, beaters mounted on horseback have ridden clattering down the stream to drive the fish into the nets. This, of course, could only be done in suitable streams, like the Awatere.

Another method was to leave the nets in position overnight. The fish feeding in the rapids got into the current of the race and were swept into the nets.

The Grayling.

Season.—The grayling feeds on the fresh-water algae, especially the kind known as *tuhou-kura*. These are plentiful in the later summer and autumn months, especially March and April. The fish then become very fat, and are often cleaned by twisting a stick round the entrails, which are easily withdrawn by pulling through the vent (*kotore*).

Cooking, &c.—If partaken of too heartily when very fat the fish are liable to make one ill. In this respect the grayling is *he ika kino* (a dangerous fish) and must be used with restraint. Otherwise they are good eating, and possess none of the muddy flavour usually associated with fresh-water fish.

For preserving they are grilled (*tauraki*) over a number of horizontal sticks set above a fire of embers. When cooked they are packed in baskets and stored for future use.

Names.—The general name is *upokororo* ("head full of brains"), derived from the fatness which characterizes it. The small ones are also called *rehe*, and the large size *tirango*. This is another example of naming different sizes of the same fish. Unless these different names are followed up, one is apt to think from the number of Maori names that there are more kinds of fish than actually exist.

(3.) *Leading-net to a Fish-trap* (Purangi).

The *purangi* is a leading-net used to connect an eel-trap (*hinaki*) to the end of a fish-weir. Besides connecting the trap, it serves, by means of its funnel shape, to direct the fish into the comparatively small opening of the trap. Being made with a large open mesh, it allows a large volume of water to escape without passing through the trap. The current is yet directed to the mouth of the trap, and sweeps the fish into it. In spite of this escape of water, the current is so strong that the net often gives way and the *hinaki* is lost.

With the Ngati-Porou the *purangi* consists of a funnel-shaped net with a hoop at either end. In Mr. Downes's* excellent paper on eel-weirs he states that with the Whanganui and Nga Rauru tribes the net without the hoop is called *purangi*, whilst the net fitted with the two hoops and a square or triangular frame to support the larger hoop is termed a *poha*. The following description is of an average-sized *purangi* net in the possession of Paratene Ngata, of Waiomatatini :—

The net, of the usual flax strips, is begun with a simple-loop commencement of twenty-three loops. The meshes are 2 in. As the depth increases, additional loops are introduced gradually, so that eighteen extra meshes are added in twenty-five rows. There are thus forty-one meshes on the last row, and on the two sides being joined up in the usual way there are twenty-four meshes at the small end and forty-two at the large. The stretched net is about 46 in. long.

The Hoops.—For the smaller end a length of *aka tea* (vine) is run through the commencing-loop in place of the supporting-strand of flax. The ends are brought round into a hoop, overlapped, and lashed so as to form a hoop 15 in. in diameter. This is called *te whiti o te ngutu o te hinaki* (the hoop for the mouth of the fish-trap). A larger hoop of supplejack, 30 in. in

* T. W. Downes, Notes on Eels and Eel-weirs, *Trans. N.Z. Inst.*, vol. 50, pp. 296–316, 1918.

diameter, is fixed to the larger end of the net by running strips of flax through the marginal meshes, winding round the hoop, and tying at intervals.

Attaching Net to Fish-trap.—The small end of the net is fitted with the hoop just inside the mouth of the *hinaki*. The size of the hoop is really adjusted to fit against the hoop of the trap, which is just inside the circumference of the mouth, or *puwhatero*. The two hoops are tied with strips of flax in a chain knot of overhand knots. Plate 110, fig. 1, shows Paratene Ngata doing this.

Fish-weirs.—The fish-weir with which the above net was used belonged to the smaller variety known as *pa tauremu*. *Pa* is the generic word for "weir," and refers to the blocking of the stream. The weir is erected on a *taheke*, or rapid, which, of course, must be selected so as not to be too swift or too strong. A piece of dry wood is thrown into the stream to judge the line of the current, and so aid in selecting the site for the apex of the V-shaped weir. Stakes of manuka, and the leafy top of the same bushes, are prepared beforehand. The stakes, about 5 ft. long, are sharpened at one end. Two strong stakes are driven in parallel to each other, and at slightly less than the diameter of the large hoop apart. Other stakes a few feet apart are then driven in, in lines diverging up-stream to form a V. Two horizontal rails of manuka rods are lashed to the stakes with strips of flax. The lower rail is a few inches above the bottom, and the other somewhere about the level of the water. The brushwood is now laid against the inner side of the two arms of the weir. The pressure of water will usually serve to keep them in position, but they may be tied here and there. The brushwood must be so arranged to have a slight space in front of the two posts first driven in. It is sufficient to run the brushwood arms back a few yards. The arms may then be continued back by piling up stones from the rocky bed of the stream. It is not advisable to have too wide a weir, as the force of the water may carry away the net. The space between the two first (or apical) stakes has been kept clear.

Setting the Net.—The *purangi* net with the attached trap is now placed in position. The large hoop is placed on the inner side of the two apical stakes which catch part of the sides of the hoop. The hoop is pushed down so that it touches the bottom, and part is caught by the lower cross-bar. The other bar placed across the inner side of the two stakes is tied so as to catch part of the upper circumference of the hoop. The hoop is thus held securely in position against the rush of the water down the race. The fish-trap floats below, but it may be necessary to place a stone on it to keep it down and place its opening in the direct current from the opening of the weir. Plate 110, fig. 2, shows everything very clearly.

It is usual to attach a rope from the fish-trap to one or more stakes, to save it in case of the leading-net giving way. The art in making the nets is so to arrange the meshes that the completed net sits evenly when it is set to the weir. If the sides are uneven the trap will not ride properly in the current, and if the current is directed to the side of the net, instead of the opening of the trap, fish are liable to escape through the meshes.

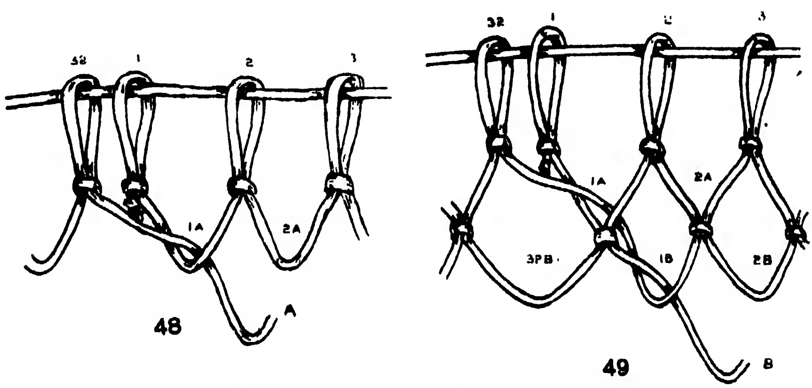
The Fish.—This type of trap-and-weir arrangement is usually associated with the catching of eels. They must, however, be the eels which are moving without waiting for the floods. When the migrating eels (*tuna heke*) come down in the March floods, the weir described is too flimsy to withstand the rush of waters, and the nets are usually taken up. Grayling are often caught in these traps.

The *kokopu (Eleotris gobioides)* are caught in large numbers as late as March. The weir described was made in the beginning of April by members of the Dominion Museum Ethnological Expedition, under the direction of Paratene Ngata. Not a single *kokopu* was caught. The name *kokopu* on the west coast of the North Island is applied to *Galaxias fasciatus*, which on the east coast is called *para*. At Lake Taupo *kokopu* is applied to *Galaxias brevipinnis*. The name *kokopu* is used in the Cook Islands for a fresh-water fish, specimens of which were brought back by Sir Maui Pomare. The above type of weir is also called a *pa kokopu*.

The *papauma (Cheimarrichthys fosteri)* is also caught in large numbers. The same fish is caught in the eel-traps in the Whanganui River, where it is called *papanoko*. We secured a large number in April, when they were full of roe.

(4.) *Combined Leading-net and Fish-trap* (Hinaki Purangi).

This net is now somewhat rare. A good idea of it can be formed from Plate 109, fig. 1. The previous net, the *purangi*, is merely a leading-net to a *hinaki;* but this net combines the functions of both, hence the double name, *hinaki purangi* (the *purangi* fish-trap). It must have occurred to



FIGS. 48, 49.—The side join of the *hinaki purangi*.

the early fisherman that the force of water sweeping down the race and rushing with some violence through the *purangi* would effectively prevent the fish from turning back. The special arrangement in the entrance to the stiff fish-trap, *hinaki*, to prevent the escape of fish, was therefore unnecessary. The lengthening of the funnel and the closure of the small end was all that was needed, combined, of course, with a mesh small enough to prevent even small fish from being swept through the closed end by the current. The results of these observations were materialized in the *hinaki purangi*, which is leading-net and trap combined in one piece, with the same material and technique throughout.

The net required is 15½ ft. long. It is begun at the small end on a supporting-strand by the closed-loop commencement with thirty-two loops. After the loops are set up the technique differs from all the nets so far described. The usual method of netting backwards and forwards by twisting the supporting-strand and then joining up the sides is departed from: this was probably due to the length of the net. Thus when the

thirty-second loop is completed, instead of turning back, as in fig. 23, the last loop and the first loop on the supporting-strand are slid round till they come together (fig. 48). The netting-strip, A, is passed through the first open loop, 1A, and, after gauging with the fingers, is fixed to the second open loop, 2A, with the usual netting-knot (fig. 49). This forms the first mesh, 1B, of the second row. It is continued in 2B, and continues round till it comes to the loop 32B, when this loop is netted to the loop 1A, which was passed over in fig. 48. This completes the second row of meshes. The netting-strip, B, in fig. 49, is now slipped through the next mesh, 1B, spaced with the fingers, and netted to the next loop, 2B. This process is continued, and the net is made like a tube, each row of meshes being completed and closed before going on with the next. The process is quite simple. Each time a new row is commenced the netting-strip passes through a mesh to the right of the last commencement; and the line of side joins, easily seen from the interlacing effect, runs diagonally down and to the right. In the completed article it shows as a long spiral. Thus there is no break in the continuity of the netting process.

Plate 109, fig. 2, shows the closed-loop commencement on the supporting-strand, and the fine ½ in. mesh at this end. With the tubular net flattened out it is 7½ in. wide: this is maintained for about 4 ft. The mesh increases to ¾ in. At 5 ft. it is 10 in. across and the mesh 1 in.; at 6 ft. 6 in. it is 13 in. across and the mesh 1¼ in.; at 7 ft. 6 in. the width is 16 in. and the mesh 1½ in. From now on the mesh increases to 3 in. at the large circumference, which is 4 ft. in diameter and 15½ ft. from the commencement.

A hoop of two pieces of twisted supplejack is fixed to the larger end. The hoop is 45 in. to 48 in. in diameter, and is lashed with a chain knot to the marginal meshes. At the small end a strong strand of flax is passed through the closed loops of the commencement. It is drawn taut and tied to close the opening.

A stone sinker or anchor (*punga*) is tied to the end of the closing-strand at the small end when the net is set.

Method of Use.—This net is used with small weirs in exactly the same manner as the previous net. In constructing the weir the two apical stakes are driven in to suit the diameter of the large hoop. The hoop is maintained in position by the two apical stakes and upper and lower cross-bars. The anchor having been attached, the small end of the net is stretched out to lie in the direct current from the race. It is then dropped, and the stone helps to keep it in position.

As before, the important thing is to have the apical stakes driven in the right position, and a properly constructed net set right so that the current will sweep straight down the middle line of the net. In spite of the large 3 in. meshes of the leading part of the net, the smallest fish are swept down into the tubular fine-meshed end of the net. There they are packed like sardines by the force of the water, and not even eels can turn back: they speedily die. If through error in placing the apical stakes, or fault in construction or setting the net, the current is directed even slightly to the side, fish will escape through the larger meshes.

Plate 111, fig. 1, shows a side view of the *hinaki purangi* set to a weir in the Waiapu River. It will be noticed that strands of flax have been tied to the hoop and braced to stakes in the arms of the weir. This was to tilt the upper part of the hoop forward to get the right lie for the net, which is tightened up perfectly by the current. Plate 111, fig. 2, shows the

opening of the net when looking down the weir. It also shows up the brushwood arms of the weir very well.

The net may be left in all day, but the main catch is made at night. The owner of the weir usually lifts his net very early in the morning. The nets are so easily seen and lifted that it is safer to put temptation out of the way of the passer-by. To remove the fish, the anchor is lifted, the strand untied, and the catch poured into baskets through the small end.

The Fish.– The fish caught are the same as in the previous net. The weir in Plate 110, fig. 2, was made first as an experiment, for ethnological purposes. Besides *papauma*, one grayling was caught. Grayling had not been caught in that part of the Waiapu River for over twenty years. As the grayling goes in shoals, it was held that there were others about, and our experimental weir, being close to one side of the stream, had caught a fish from the flank of a shoal feeding farther out on the rapids. The new weir was immediately built so as to overlap the first and take in almost the rest of the stream. The next morning we caught over forty grayling. The news spread, and many unbelieving Ngati-Porou came to see them. The fish-weir industry received a great impetus, but rain came on and stopped further operations.

D. Baited Trap-net.

In this class there is only one example. It differs in construction and principle from the baited bag-nets and from the set trap-nets. Hence it is set in a class by itself.

Torehe.

The *torehe* is a circular net that is kept flattened out by supplejack radials, and can be closed at will by a line passing round its circumference. In Plate 113, fig. 1, it is held vertically instead of lying horizontally, in order to show the construction. It is also called a *toemi.* It consists of a net, radials, bait-rest, sinker, and line.

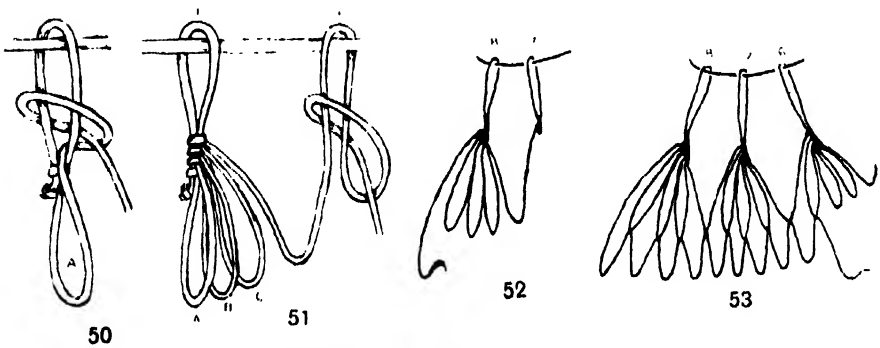
The Net.—The net is commenced in a different manner from those described. It is begun by the closed-loop commencement, but three additional loops are tied to each closed loop before the next closed loop is made on the supporting-strand. Thus the first closed loop is made as in figs. 3, 4, and 5. This loop is treated as the lower end of a mesh on which to make an additional loop, as in fig. 31. Thus in fig. 50, after tying the closed loop 1, the netting-strip is looped below it, passed through the closed loop 1, and a netting-knot made in the usual way. The loop A is, of course, gauged with the left forefinger. The netting-strip is again passed through the closed loop 1, and the loop B gauged and tied. This is repeated a third time, and we have fig. 51 with the closed loop 1 to which are attached three additional loops, A, B, and C. The closed loop 1 is called a *puriri.* The netting-strip is now carried over the supporting-strand and a second closed loop, 2, is tied (fig. 51). The netting-strip between the two closed loops is gauged with the left finger to coincide in level with the three loops that have been made.

To the closed loop 2 three loops are attached, and this procedure continued until eight closed loops, or *puriri*, have been made on the supporting-strand. Each *puriri* carries three loops or meshes, making twenty-four in all. Between the eight *puriri* there are seven connecting-loops, thus making thirty-one loops to net to in the next row. The supporting-strand is now twisted so that the last mesh of the row may be brought

back to the left and the netting of the second row be continued from left to right. The netting-strand is brought down from the upper part of the last mesh, gauged to a full-sized mesh, and netted to the last (now first) mesh of the first row (fig. 52).

From now on it is plain netting. The netting-strand is netted to the lower end of the other two meshes of the same group, and then to the loop connecting with the next *puriri* (fig. 53). Thus the groups of three and the connection-loop are netted in turn until the last mesh is reached. The supporting-strand is turned, and the third row commenced from the left in the usual way by gauging a full mesh and then netting to the meshes above in turn.

Except for setting up groups of three at the commencement, the netting proceeds as in the ordinary bag-net. In the *torehe* net, however, no extra meshes are introduced after the first row, but in order to carry out the circular plan of the net the meshes of succeeding rows are increased in size. The number throughout, however, is restricted to thirty-one in each row (see Plate 112, fig. 2). In good work the meshes may be gauged



50 51 52 53

FIGS. 50–53.—Commencement of *torehe* net.

on the fingers, but as they increase in size they are judged by eye. When a sufficient number of rows have been added—say, eight—the sides of the net are brought together and joined up in the usual manner (fig. 35). The joining adds the extra mesh which makes thirty-two in each row.

Waiheke Puha, of Te Araroa, demonstrated the Ngati-Porou method of finishing off the net. The supporting-strand is not removed, but tightened up and tied so as to bring the loops of the eight *puriri* close together.

The net has now assumed a circular form, and the reason for grouping three meshes to each *puriri* and the gradual increase in the size of the meshes is obvious. The usual size is from 24 in. to 26 in. in diameter, but larger ones may be made.

Radials of split supplejack are prepared. Four pieces a little longer than the diameter of the net are needed. They must not be split too thin, as they are then liable to break. Before inserting these the net is marked off for the first radial. A piece of flax is tied to one of the knots between two meshes on the circumference. The net is doubled over, and the meshes are picked up in pairs, commencing with the meshes on either side of the marked knot. The next pair contains the second mesh on either side of the knot. This is continued until the last pair is picked up. The knot between them

will be exactly opposite to the marked knot. It also is marked with a piece of flax. Thus between the two marked knots there will be exactly sixteen meshes on either side of the circumference. It might be just as easy to count off sixteen meshes from the first marked knot, but the picking-up of two pairs makes no mistake possible, and—well, the Maori did it in that way.

The radials are about 28 in. long. The first supplejack radial is now threaded through the meshes from marked knot to knot, care being taken on passing through the central part to keep four *puriri* on either side. The second radial is run through at right angles to the first, making four quadrants with eight meshes and two *puriri* in each. Two diagonal radials are now put through. The four radials divide the net into eight equal sections with four meshes and one *puriri* in each. The net is drawn out and tied at the circumference over the knots that coincide with the spreaders. After tying one end of a radial spreader, the radial is pushed out until the net is taut, and then the other end is tied. The radials are called *wanawana*, and are counted as eight, though there are really only four pieces of supplejack. The supporting-strand is further tightened.

The bait-rest (*pae mounu*) is made of two strips of split supplejack. The two ends of one piece are pushed up through the bottom so as to pass up about 1 in. or so on either side of the centre. The second piece is treated

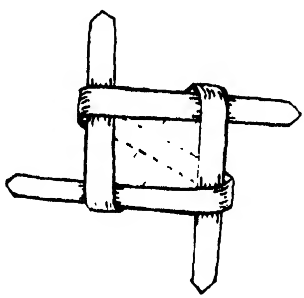


FIG. 54.—Bait-rest for *torehe*.

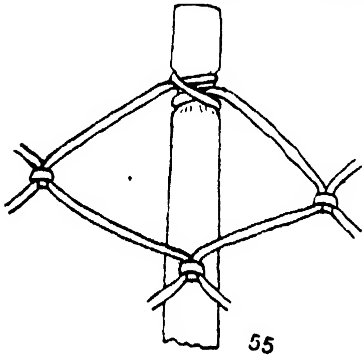
similarly, so as to cross the other on the bottom at right angles. There are then four pieces projecting vertically through the bottom of the net. One piece is bent at right angles to lie in the plane of the net; the piece next to it is bent horizontally and crossed over the first at right angles; the third crosses the second at right angles; and the fourth, after crossing the third at right angles, has the end pushed under the first, as in fig. 54. This locks them securely, making a rest with four free limbs projecting 1 in. or so. A broad strip of flax is wrapped successively round each limb, so that each round overlaps the preceding one, as in the technique of a fly-flap. A few turns are made and the projecting limbs trimmed off. A thin strip of flax is attached to the bait-rest for tying on the bait.

A stone sinker is tied to the underside of the net, opposite the bait-rest.

The net is completed by passing a cord through the circumferential meshes. The ends are tied together to form a loop, and a line is tied to the loop.

In the *torehe* demonstrated at Te Kaha, Bay of Plenty, by Waikura, of the Whanau-a-Apanu Tribe, there are some differences in detail. The net is finer, the first meshes being measured on the little finger, increased to the

thumb, and then judged by pulling on the mesh. The netting is continued until it reaches a depth of 12 in. to 14 in. The spreaders are measured after insertion, cut off, and a nick cut near the ends. The free margin of the appropriate circumference mesh is itself attached to the nick on the radial by means of a clove hitch (fig. 55). There is no extra piece of flax used in tying. The bait-rest is made in a different way. The supporting-strand used whilst the net is being made is removed. A piece of split supplejack 9 in. long is run through the closed loops of the *puriri* to take the place of the supporting-strand. This piece is bent round into a circle with the ends overlapping for 1 in., and the overlapping ends are lashed together. The centre of the net is thus occupied by a supplejack circle 8 in. in circumference. Another piece of split supplejack about $6\frac{1}{4}$ in. long is bent into an inverted U, placed vertically over the circle, and the two ends lashed to opposite points on the circle. To the upper surface of this loop two short pieces of split supplejack are lashed in a cross with the plane horizontal. This forms the bait-rest, and is provided with a strip of flax for tying on the bait.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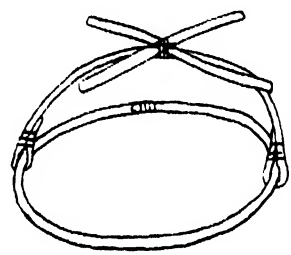
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FIG. 55.—Clove-hitch attachment of mesh to radial.
FIG. 56.—The *pouraka torehe* bait-rest.

The circle, hoop, and cross-piece forming the Whanau-Apanui bait-rest is called by them a *pouraka torehe*, to distinguish it from the *pouraka koura*, or bag-net for crayfish. The Ngata-Porou do not use the term in this sense. This form of bait-rest gives a much neater appearance to the net. That the term *pouraka* is old amongst the Whanau-Apanui people the following incident proves: Tamahae, the famous warrior of the Te Kaha region, whilst passing along the beach below the hut of Korokoro, who had slain his brother Teehu-tu, was greeted with a taunting remark by Korokoro. Tamahae replied. "*E tika, e tika! Akuanei o kauae meatia rawatia hei pouraka torehe mo Paringaere*" ("Is it so! Soon your lower jaw-bone will be made into a *pouraka torehe* [bait-rest for a *torehe*] to use on Paringaere"). Paringaere was a well-known fishing-ground. The threat in the reply was to use the lower jaw-bone to form the inverted U to carry the cross-piece and bait. Truly it was an insult of the greatest intensity!

The sinker in these nets was fastened below to the supplejack ring of the *pouraka*. The loop of cord round the circumference was termed the *ngakau*. By removing the radials and sinker the net could be rolled up in small compass and carried about.

Method of Use.—The best bait for the *torehe* is the cephalothorax of the crayfish with the carapace and legs removed. This corresponds to the

tuke, and, being tough from skeletal reinforcement, has not to be so often renewed. The bait is tied on to the cross-piece by taking turns with the bait-string over it and round the arms of the cross-piece. The net can be used from a canoe or amongst the rocks. It is placed flat on the water, and sinks to the bottom. Care must be taken to pay the line out quickly to prevent any strain or pull prematurely closing the trap. On reaching the bottom the slack of the line is drawn in carefully until the trap can just be felt. The tugging of the fish at the bait can be distinctly felt on the line. The line is sharply jerked, which closes in the circumference of the net, the flexible radials bending readily (see Plate 113, fig. 2). The line is drawn up quickly and not allowed to slacken. Large fish are caught head downwards in the trap, and even if the tail is sticking out the scales catch against the meshes of the net and prevent escape. Two or more fish may be caught at a time. On bringing the trap into the canoe the circumferential loop is slackened off and the fish removed. The supplejack radials are further straightened out, and the net dropped back again.

The Fish.—All kinds of fish are caught, from *moki* and *tamure* (snapper) to the smaller fish that abound about the rocks and reefs. Some of the smaller fish that remove the bait from hooks with impunity fall an easy victim to the *torehe.* Such a fish is the *kokiri* (*Cantherines convixirostris* Guenther) (leather-jacket). The *hiwihiwi* (*Chironemus fergussoni*), *tupuku*, *nguture*, *tangahangaha*, and *koeaea* (*Coridodax pullus* Forster) (butterfish), are amongst those caught. The region round Te Kaha is especially rich in varieties of fish. The *nanua* (*Chironemus spectabilis*) may also be caught.

Remarks.—By constant use the supplejack radials become weak and lose their spring, but fresh ones are easily put in. When jerking the line of the net, the stone sinker gives a counter-pull and thus serves a double purpose.

The net would be extremely useful to naturalists for collecting specimens of the smaller sea-fish. There is no net that would give more satisfaction to women, children, and indifferent fishermen. It is so easy to make, and so efficacious, that it would pay seaside campers and yachtsmen to test its possibilities.

CONCLUSION.

Acknowledgment has been made throughout these pages to various men from whom information has been received. Where all have imparted cheerfully, it is impossible to name more than a few. Acknowledgment must again be made to Mr. J. McDonald, of the Dominion Museum, for his valuable photographs, without which this article would lose much of what little value it has.

There are other nets in other regions yet to be described. Such are the nets of the dredge-rakes and dredge-nets of Rotorua, the *pouraka* of Taupo, and various nets from divers places. It is hoped, however, that the description of the netting technique and the concentration on the articles made in one area has opened up the subject sufficiently to enable others to supplement and help in completing, as far as possible, the records of the netting-craft of the Maori branch of the Polynesian race.

Food Values of New Zealand Fish.

Part 5: The Fats of the Red Cod in relation to its Food.

By C. L. CARTER, M.Sc., A.I.C., and J. MALCOLM, M.D.

[*Read before the Otago Institute, 11th November, 1924; received by Editor, 31st December, 1924; issued separately, 10th May, 1926.*]

IT has been established by numerous observations and experiments that the fats stored by animals are to a large extent derived directly from the fat of their food: thus the feeding of pigs on fish-meal, &c., affects the flavour of the bacon, and it has been proved by direct experiment that the fat of a dog fed largely on mutton-fat acquires the characteristics of mutton-suet. Also, unusual fatty acids such as erucic acid can be detected in the fat of an animal fed on fat containing that acid. It has also been inferred that under natural conditions fats can pass with little change from the body of one animal to another. As was indicated in Part 4 of this series, if this holds good for fish we might obtain evidence as to their food from the study of their fat.

So far as we can find, there are no observations on the subject except those of Rosenfeld, who fed carp and goldfish on mutton-suet, and found that the fat laid on by the fishes was mutton-fat. He also compared the fat of some marine forms of life with the fat of their food where the latter was "tolerably well known," and found a fairly close agreement.

An opportunity for procuring suitable material for similar observations presents itself annually in Dunedin Harbour in the case of the red cod (*Lotella bacchus*), which in the late summer and autumn subsist almost entirely on the shoals of whale-feed (*Munida gregaria*) that frequent the harbour at that time. Later in the year red cod become scarce in the harbour, and are caught in deep water outside the Heads. At this time their stomachs are free from the debris characteristic of a whale-feed diet, and what their food then is is uncertain.

Through the kind co-operation of the Marine Biological Station at Portobello we obtained samples of whale-feed, and of red cod when their stomachs were quite full of partially digested whale-feed. These were all obtained early in March. Later in the year (end of September) we were supplied with two specimens of red cod caught outside the Heads, when the stomachs showed no sign of whale-feed and contained only some slimy mucus.

The composition of whale-feed has already been the subject of a paper by the Hon. G. M. Thomson and G. S. Thomson, but we decided to repeat the analysis on samples taken at the same time as the fish were caught, and analysed by the same methods as were used for the fish.

Since the fat, or oil, of the liver in vertebrates differs from that of the other organs and depots of the body, we examined the liver-fat separately from that of the flesh.

METHODS.

Except in the case of the livers, the minced and weighed material was first extracted twice in succession with double its bulk of alcohol (approximately 90 per cent.) at room-temperature, and the residue was dried in the

sun, extracted with ether (Soxhlet), and the fat so obtained was weighed separately. The alcohol of the alcoholic extract was distilled off, and the residue, after drying, was also extracted with ether, and so we obtained the fat that was soluble in both alcohol and ether, as well as the fat soluble in ether only. In all the operations we avoided exposure of the fats to heat and oxidation as far as was practicable in our circumstances.

The fish-livers were so fatty that we found it best to extract some of the fat with ether by shaking up and drawing off the ethereal layer before attempting to dry completely. The usual extraction method then followed, and all ether-soluble material was combined and weighed.

The fatty acids and "unsaponifiable" material were obtained from 8 to 10 grammes of fat thoroughly saponified with alcoholic potash. After diluting the soaps and driving off the alcohol, ether was used in separating funnels to remove the "unsaponifiable" part. The fatty acids were then obtained by acidifying the residue.

The iodine values of the fatty acids and oils were estimated by Wijs's method, and the mean molecular weight by titration with one-fiftieth normal alkali.

The results are given in the table.

—	Whale-feed.	Red Cod (A) feeding on Whale-feed.		Red Cod (B) feeding in Deep Water.	
		Flesh.	Liver.	Flesh.	Liver.
Water percentage	..	79·0	44·3	81·0	46·0
Solids by difference.. ..	..	21·0	55·7	19·0	54·0
Fat percentage	1·3	0·8	47·3	0·9	40·4
Nature of the fat*	Brown pasty mass	Brown pasty mass	Dark-red oil	Pasty mass	Red oil.
Percentage of the fat soluble in alcohol and in ether	80·0	77·0	..	68·0	..
Percentage of "unsaponifiable" matter	6·9	5†	10·8	5†	9·6
Nature of fatty acid—Solid at	15° C.	15° C.	15° C.	15° C.	15° C.
Iodine value of the fatty acids (Wijs)	138·8	139·2	113·1	135·5	111·3
Iodine value of the liver-oils..	..	..	85·0	..	72·0
Mean molecular weight of fatty acids	309·0	334·0	282·0	335·8	283·0

* All these fats contained appreciable amounts of lecithin, as shown by methylamine during the saponification. The liver-oils gave black resinous pitch-like acids denser than water. † Approximate.

Discussion of Results.

Our analyses indicate that there is a very close agreement between the nature of the fat of whale-feed and the body-fat of red cod (A) at a time when it was undoubtedly feeding on whale-feed: thus the iodine values (approx. 139) agree, also the physical appearances and the percentage of the fat soluble in both alcohol and ether. The mean molecular weights of the fatty acids in the two cases differ by 26—a figure which corresponds approximately to two carbon atoms with attached hydrogens. This is interesting when one remembers that, according to modern views, fats in the body are split up or synthesized by removal or addition of two carbon atoms at a time.

As we had expected, the liver-fat of the red cod differs from that of the flesh, and here also there are interesting relationships, for the mean molecular weight of the liver fatty acids differs from that of the flesh by 52—which corresponds to four carbons; also the amount of unsaturation is proportionate to the molecular weight: thus the ratio of 334 (mean molecular weight) to 139 (the iodine value) is practically the same as 282 to 113. It has been shown by Leathes and others that in mammals the liver-oils are always less saturated—*i.e.*, have a higher iodine value—than the body-fats. Here there seems to be the opposite condition; but the figures may be accounted for by assuming that the unsaturated fatty acids of the body-fats had had four carbon atoms split off, and that in the process of splitting some of the unsaturation had disappeared; otherwise, owing to the smaller size of the fatty-acid molecule in the liver-oil, the iodine value would have been higher than it is.

In the examples of simultaneous analyses of fat of food and fat of consumer of the food given by Rosenfeld none is in such close agreement as are our figures. We would have been glad, however, if he had examined the "consumers" at another season of the year, when the nature of their food was less obvious, or even different, for it would have been interesting in comparison with our results in the case of red cod B. These, as already stated, were caught six months earlier, or later, in the life of the cod—unfortunately we cannot say which with certainty, for the scales were not examined, but from the weight of flesh it is probable that the red cod B were either younger fish or fish of the same age as A but in poorer condition.

In these "winter" fish the main characteristics of the fats remain very much the same as in the "summer" fish—*e.g.*, the iodine values and mean molecular weights of the fatty acids are similar. The percentage of fat in the flesh is 0·1 higher in the winter fish, but this is within the experimental error, and there may have been wastage of the protein part of the flesh. Incidentally, our analyses confirm those of Mrs. Johnson (Part 2 of this series) in finding that red cod is poor in fat.

There are, however, certain differences to be noted:—

(1.) The fraction of the total fat that is soluble in both alcohol and ether is 77 per cent. in A, 68 per cent. in B.

(2.) The livers of the winter fish were smaller relatively to the weight of flesh (ratio of weights respectively 1 : 15) than those of the summer fish, where the same ratio was 1 : 10.

(3.) The percentage of liver-oil was also less—40·4 for winter fish, 47·3 for summer fish.

(4.) The iodine values of both liver-oil itself and the fatty acids of the liver-oil were less in the winter fish.

Although these points of difference are small when looked at singly, they all indicate a certain degree of depletion of the reserves, and, taken in conjunction with the empty state of the stomach, point to a condition of semi-starvation.

The explanation which we think best fits in with the data we have obtained is that the main food of this fish for the whole year consists of whale-feed. During the summer and autumn the red cod gorges itself on this food, and fattens so far as its liver is concerned. In winter it retires to deep and colder water. Here, owing to lessened metabolism, and possibly lessened food-supply, it lives largely on its reserves till the whale-feed season again occurs. During the time of plenty the character of the fat acquired has a direct relationship to the fat of the food.

Unsaponifiable Material.

We paid special attention to the nature of the unsaponifiable matter in these marine oils, for the following reason: One of us (C. L. C.) has already demonstrated that "mutton-bird oil" consists mostly of cetyl-oleate and other esters of cetyl alcohol. For some time we have been investigating the fate of cetyl alcohol in the body, and, incidentally, its origin in the mutton-bird. One possibility that presented itself to our minds is that the oil may be an indigestible (*i.e.*, unsaponifiable) residue of the fat present in the food of the bird. The finding of cetyl alcohol in whale-feed or other shell-fish, or in the fats of any form of marine life, would lend support to such a view, but, in spite of much time and labour spent in crystallizing out the unsaponifiable constituents, no trace of cetyl alcohol was found; on the other hand, there was clear evidence that the great mass of it consisted of cholesterol in more or less pure form.

In conclusion, we beg to thank the University of Otago for facilities given us for carrying on this work, and to acknowledge financial assistance received from the New Zealand Institute Research Fund.

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Food Values of New Zealand Fish.

Part 6: The Vitamin-A Content of Mutton-bird Oil and of some Fish-oils.

By John Malcolm, M.D.

[*Read before the Otago Institute, 9th December, 1924; received by Editor, 31st December, 1924; issued separately, 10th May, 1926.*]

Since the beginning of the present century two great advances have been made in our knowledge of dietetics. One, originating in a better knowledge of the chemical constitution of the protein molecule, has led to the recognition of the importance of the quality as contrasted with the mere quantity of protein in diet; the other is the discovery of the need for accessory factors, or vitamins, in addition to the protein, salts, carbohydrate, and fat.

Of late years a large amount of work has been done on the presence of vitamins in various foodstuffs, and it seemed desirable to carry out similar investigations in New Zealand. This paper relates to the estimation of vitamin A in some marine products.

Method.

The mode of procedure commonly adopted in this kind of work is now so well established that it is unnecessary to set it out in detail, except so far as local conditions are concerned. Litters of young albino rats, weaned about the thirtieth day, were fed on a diet consisting of—Casein, 19·3 per-

cent.; starch, 54·3 per cent.; lard, 16·1 per cent.; "Marmite," 4·4 per cent.; salt mixture (McCollum), 5·3 per cent. This diet is referred to in this paper as "diet 8." The rats were weighed twice or thrice a week till symptoms of lack of vitamin A set in and treatment began. Usually they were then weighed every second day, but, owing to pressure of other work, it was not practicable to have this done, and the food given, always at the same hour of the day. The temperature of the rat-room was kept at 17°–22° C. The experiments were begun in June, but it was not till early in September that difficulties in regard to the diet were overcome. These difficulties arose from the use of a dried yeast as source of vitamin B, faulty preparation of the salt mixture, and imperfect purification of the casein. The treatment ultimately adopted for the casein was a combination of that used by Sherman and by Hopkins—viz., extraction with boiling strong alcohol three times in succession, followed by heating for eight or more hours on an iron tray. In our case that could be done only in quantities of 400 grm. at a time, and, owing to the stage of growth of the litters, there was no time to stop for the purpose of accumulating a large stock of uniformly mixed, treated casein. Hence there is the possibility that some batches of diet may have been made with casein that still contained traces of vitamin A. That this did not occur to any appreciable extent is shown by the curves in charts 1 and 2, which are arranged so that the dates synchronize. Any fault in the purification of the diet would be shown more or less in all simultaneously, for the food was made up every four or five days, and all were fed alike. The only instance of an otherwise unexplainable rise is shown round the dates 18th to 21st October. (See rise in curve D, and possibly E_4 and E_1.)

The lard used was well aerated for at least eight hours on a boiling-water bath, and then filtered. Neither the other ingredients of the diet nor the mode of preparation call for any special comment at this stage. The oils tested were administered orally by means of small bulb-shaped pipettes, the delivery of which was determined by weighing. The smaller doses, such as 0·01 and 0·02, were given as dilutions in olive-oil so made that the amount administered was about 0·08.

MUTTON-BIRD OIL.

This oil, as is well known in New Zealand and Australia, is obtained from the stomach of the young mutton-bird (*Aestrelata lessoni*). When killed, the oil can be expressed from the crop, and it is commonly believed to be supplied to the young by the parent birds. Along with Mr. C. L. Carter, the writer has been engaged on an investigation into the biochemistry of this oil, and we have found that rats can tolerate and utilize doses that are large in comparison to their body-weight (0·5 grm. per day) with no serious effects, although they and other animals seem to be repelled by its flavour.

The sample used was obtained fresh in May, 1924. It measured about 4 oz., and probably represented the stomach-oils of about half a dozen birds. When kept undisturbed in the stock bottle it had a red colour; but the samples kept in the warm rat-room, in a small bottle, frequently uncorked, and stirred by the dosage pipette, soon became pale yellow, and were then renewed.

It was easily proved that this sample of mutton-bird oil contained vitamin A. What was, of course, more difficult to gauge was the minimal effective dose for cure of xerophthalmia and for the resumption of growth. No observations were made on its anti-rachitic properties.

The following are the essential features of the experiments:—

Litter B (chart 1), four in number—two bucks and two does—were weaned on the thirtieth day (7th August). Up to the 4th September they received some of the diets used earlier than diet 8, and their growth was slow, due probably to the insufficient supply of vitamin B. On diet 8, which was begun on the 4th September, their growth was steady and rapid till between the 23rd and 30th, when the weights decreased and eye troubles began. By the 3rd October all four suffered in this way, and on this date Nos. 1 and 4 (buck and doe) were separated from the other two and given doses of mutton-bird oil (0·08 grm. each). (See chart 1.) The eyes began to improve rapidly, but the weights did not immediately increase, and after about a week of this dosage, which, in the light of later experiments, appears unnecessarily large, the amount given was reduced to 0·04 grm. daily. On this dose the weights increased till, after about five weeks, the rats had gained 43 grm. and 36 grm. respectively. They then appeared to be in good condition, their eyes had completely recovered, their coats were good, and they felt "plump" in body when handled. The mutton-bird oil was then discontinued, and, as shown by the curves, the rats continued to grow or maintain their weight for about fifteen days, and then began to decline in health, to lose weight, and to develop eye trouble afresh. In about thirty days after receiving their last dose of mutton-bird oil they had lost 35 grm. and 26 grm. respectively. On the 4th December treatment was again begun on buck 1 with a dose of 0·01 grm., increasing to 0·02, 0·04, and 0·08, and, as shown by the curve, recovery again took place. Between the 8th and 18th December doe 4 was the subject of a class experiment which need not be described here. From the 18th December to the end she received the same treatment as buck 1, and showed a similar recovery.

Meanwhile the other two of this litter were made the subjects of an experiment on "oyster-oil," to be referred to later. Following the oyster-oil, mutton-bird oil caused a rise in weight and improvement in general health exactly comparable to that of Nos. 1 and 4. On stopping the mutton-bird oil they again lost weight, and on administering 0·04 grm. and later 0·08 grm. they again increased in weight. Their curves of weight were practically the same as those of B_1 and B_4.

Experiment C: In this, two does were used—of the same age, but not of the same litter. C_1 received 0·04 grm. mutton-bird oil; the other, C_3, was used as a control. They were both kept in the same cage, and the control used greedily to lick the jaws of her companion after the latter received her dose; possibly she also ate her companion's faeces, for, so long as they were together, the control's weight was maintained at a fairly level figure; but when, on the 1st November, another control rat was substituted for the mutton-bird one she drooped and died. On the 3rd October both had well-marked eye symptoms, but, while the control's eye symptoms persisted in a subacute form for about a month and became aggravated shortly before death, the eyes of No. 1 improved within two days of commencement of the mutton-bird oil, and were completely cured in ten days. As shown in the curve, she also grew steadily while receiving the oil, and maintained her weight for ten days after the treatment was stopped. Then the weight fell and eye troubles began again. This rat was then used for an experiment on the effect of dried fish, to be referred to later.

Litter D (four does): These, like the foregoing, did not grow well on the defective diets used during the month of August. Then, from the 4th September onwards, the growth was rapid till early in October, when a decrease in weight set in (see chart 1; the curve shown is the average for all four to begin with). On the 13th October one (No. 3) died, and the

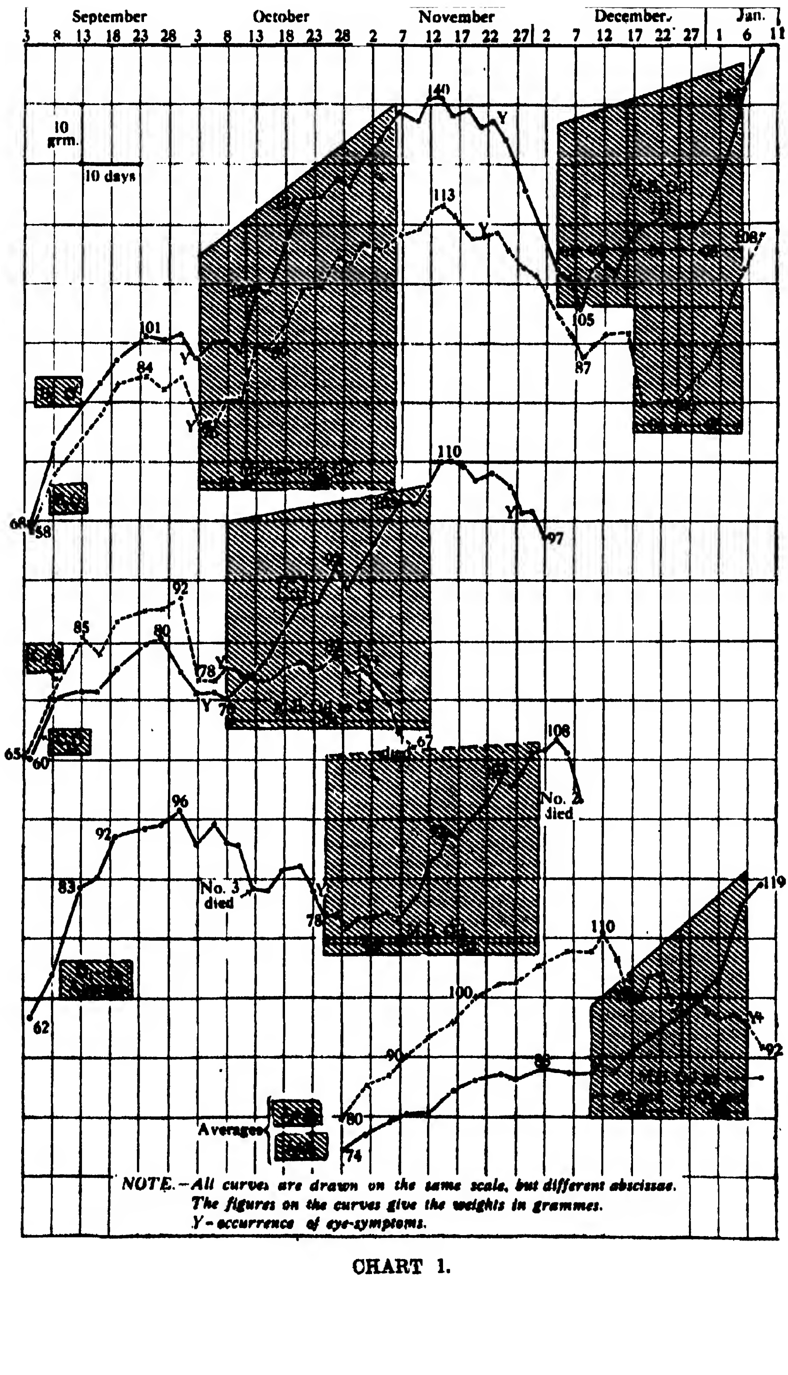
September
October
November
December.
Jan.
10 grm.
10 days
140
113
101
84
105
87
110
97
92
85
80
78
79
67
108
No. 2 died
96
92
83
No. 3 died
78
62
110
100
90
119
92
Averages
80
74
NOTE.—All curves are drawn on the same scale, but different abscissae.
The figures on the curves give the weights in grammes.
Y - occurrence of eye-symptoms.

CHART 1.

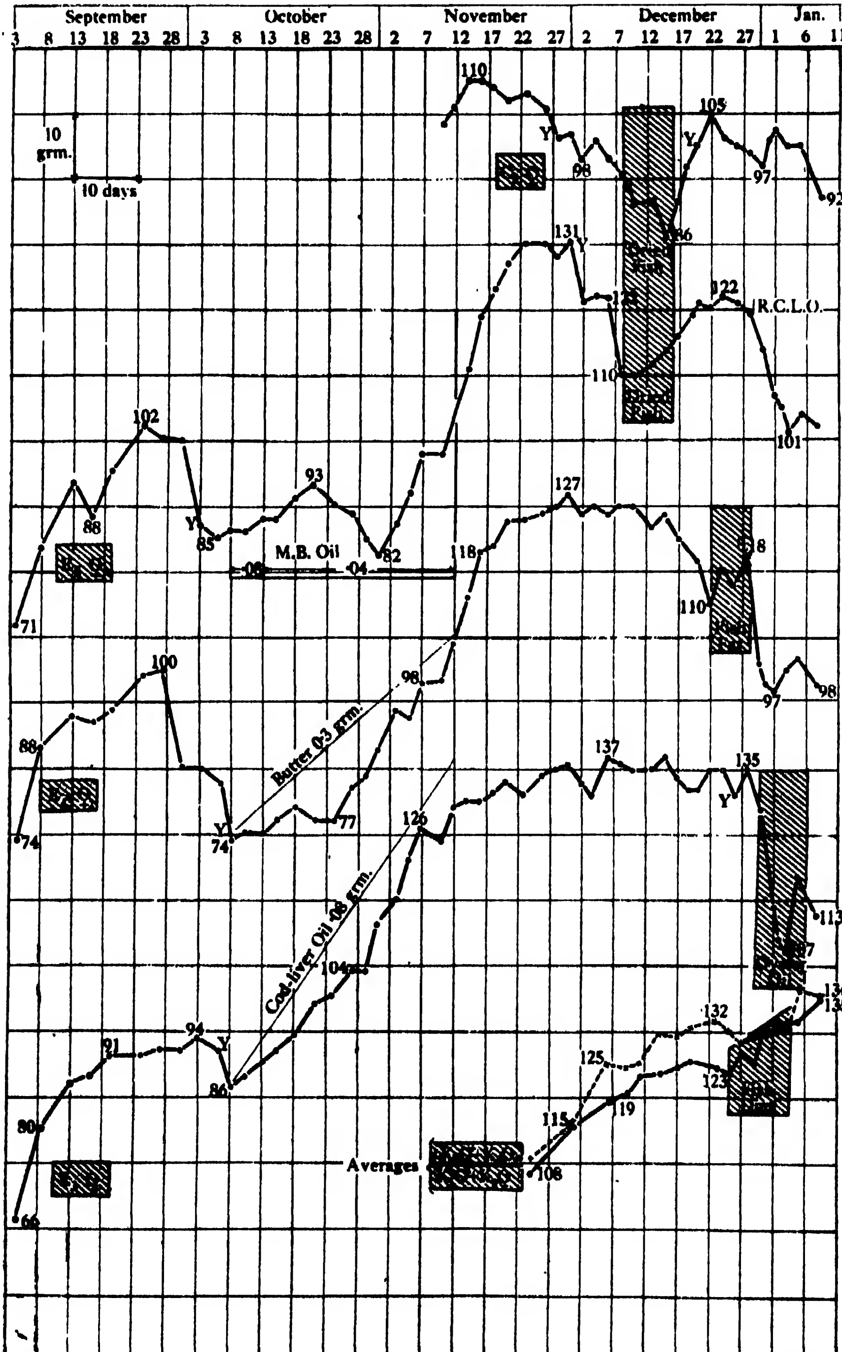
September
October
November
December
Jan.
3 8 13 18 23 28 3 8 13 18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11
10 grm.
10 days
M.B. Oil
Butter 0·3 grm.
Cod-liver Oil ·08 grm.
R.C.L.O.
Averages

CHART 2.

others were in very poor condition, with "staring" coats, "hunched-up" attitudes, and slight eye symptoms. This was followed by an improvement, which could be accounted for by imperfect purification of the casein used for a five-day quantity of diet. Then the weights dropped again, and on the 24th October the three survivors showed the typical symptoms of avitaminosis in eyes, weight, coat, &c. On the 25th October treatment with 0·01 grm. mutton-bird oil was begun. This was continued for a fortnight, during which the eye symptoms gradually disappeared, so that on the 6th November it was reported in the notes that all the eye symptoms had gone except for the appearance of a film on the right eye of No. 2. During this period, however, the average weight maintained a uniform level. What actually occurred was that No. 1 lost 1 grm., No. 4 lost 6 grm., and No. 2 gained 6 grm. The dose was then increased to 0·02 grm. daily, and a rapid rise followed in each of the three. By the 30th November—*i.e.*, after three weeks' dosage with 0·02 grm. oil—all were in good condition; their coats were still a little shaggy, but the eyes were normal, and they felt plump on handling. The oil treatment was now stopped, and for several days the weights were maintained or continued to rise. Then a rapid fall in weight set in, and two died, No. 2 on the 8th December and No. 1 on the 11th. The average curve is not carried beyond the 8th December, but it may be mentioned that the last survivor (No. 4) received further treatment with 0·02 grm. mutton-bird oil and recovered. When chloroformed on the 8th January she weighed 127 grm.

Litter E (four does): In the case of this litter also a marked effect was obtained by administration of mutton-bird oil in the two cases where it was administered. The curve of one of these, E_4, is given on chart 2. The other two rats were given butter (0·3 grm.) and cod-liver oil (0·08 grm.) respectively, in order to compare the results with that of the mutton-bird ones. The interesting feature of the result was that while there was little or no difference in the rate of growth during the time of administration of these sources of vitamin A, yet on ceasing the treatment the butter-fed and cod-liver-oil-fed ones continued to grow or to maintain themselves, without any eye symptoms appearing, for at least six weeks, while the mutton-bird-oil ones began to show eye troubles and loss of weight about eighteen days after the oil was stopped. (Compare the curves of E_4, E_1, and E_3 on chart 2.)

Litter J (four does): Two received gradually increasing doses of mutton-bird oil, and two were used as controls. The whole litter in this case had been too well fed before weaning, and were long in showing symptoms of avitaminosis (ten weeks); and the approach of a date when it was necessary to terminate all the experiments led to the mutton-bird-oil treatment being begun before the average weight had dropped much, although slight eye symptoms were evident. On the 10th December one doe began to receive 0·01 grm. oil, the other 0·02 grm., and the average weight began to increase, due mostly to an increase of the one receiving the smaller dose. The eyes soon recovered. Meanwhile the average weight of the controls showed variations, but on the whole continued to decline, and their eye symptoms became worse. On the 26th December the doses were increased to 0·04 grm. and 0·08 grm. respectively, and the result was a greatly increased rate of growth, both curves being practically the same. (Chart 1.)

When the experiment ended, on the 8th January, the oil-fed ones were in good condition and weighed 119 grm. and 120 grm. Of the controls, one died on the 7th January—weight at death, 88 grm.; the other was in very poor condition, with eyes deeply ringed with congestion, and flakes of haemorrhage—she weighed 95 grm.

The following observation may be recorded here, although it does not come under the title of the paper. Four rats were being fed on a diet deficient in vitamin B. Their weight was maintained at a fairly level figure. Mutton-bird oil was administered for over a week without effect, but the substitution of 5 c.c. of milk for the mutton-bird oil caused an immediate increase. From this it may be inferred that mutton-bird oil contains little or no vitamin B.

From these experiments it is obvious that mutton-bird oil can furnish sufficient vitamin A for rats when given in doses as low as 0·01 grm. to some, for others 0·02 grm. is required, and probably 0·04 grm. produces maximum effects in the majority.

Fish-oils.

As in other vertebrates, fat or oil occurs in fishes in the liver, and deposited under the skin, and mingled with some of the superficial muscle-fibres. That the liver-oils of all fishes contain vitamin A may be taken as established, but the fat usually eaten is that found in the other situations, and it is not at all certain that the latter is invariably a rich source of vitamin. Probably there are differences in this respect among different classes of fish, depending on the food of the fish, just as there is a difference between lard and beef-suet.

In this paper the writer can record only a few short experiments, but they are sufficient to show the lines on which further work may be done.

Tarakihi (Chilodactylus macropterus).

The tarakihi was chosen because of the high percentage of fat in its flesh. After boiling for twenty minutes the flesh was separated from the bones and spread in the sun to dry. Within twenty-four hours it was dry enough to grate finely in a mill. A sample was taken for fat-extraction (Soxhlet) and yielded 22 per cent. of fat, corresponding to 6 per cent. of the fresh material.

Experiments were made in the following ways: (1) Rats fed on diet 8 were offered some of the fish-powder; (2) rats were given doses of the ethereal extract of the powder; (3) a special diet containing the fish-meal was given.

(1.) *Addition of Fish-powder to Diet 8.*—Two does were used (C_1 and E_4). They had been used for mutton-bird-oil experiments, had recovered, and had again developed symptoms of lack of vitamin A. Although they belonged to different litters, the eye symptoms and loss of weight happened to occur in both about the same dates—29th November to 8th December. On the 8th December, whilst temporarily transferred to a clean empty cage, they were given the opportunity to eat some of the fish-powder. Within two hours 2 grm. was eaten. On subsequent days 4 grm. quantities were offered, and the residue weighed each day. By means of a separate test on two occasions it was found that each had eaten about the same quantity. This procedure was followed for eight days, and the average amount eaten by each per day was found to be 1·37 grm., which would contain 0·3 grm. of the tarakihi flesh-fat. The effects were not very striking. The curves (chart 2) show that C_1 decreased in weight during the treatment but increased afterwards, while E_4 showed moderate increase in weight. During the fish-meal period the eye symptoms improved, but only very gradually, and recovery was incomplete. They still showed signs of scratching and photophobia at a time when their weights were increasing. Within six days in C_1 and twelve days in E_4 the weights again fell, and all the eye symptoms were accentuated.

From this it may be concluded that 0·3 grm. tarakihi flesh-fat contains barely sufficient vitamin A to cure xerophthalmia or allow of much increase in weight; but it would have been better if the feeding could have been continued for a longer time.

(2.) *Administration of the Ethereal Extract of the Fish.*—This was used in one case only, doe E_1. She had recovered from avitaminosis by treatment with butter, and, about five weeks after stopping the butter, began again to lose weight and show eye symptoms. On the 19th December the right cornea was opaque, and there was a wide ring of inflammation with signs of scratching round both eyes; the skin area around the genitals was also wet and coloured brown. On the 22nd a dose of 0·06 grm. tarakihi flesh-fat was given, and this was repeated daily till the 27th. At first there was some improvement in weight, but the eye symptoms grew worse, and on the 27th the dose was trebled (0·18 grm.). This was followed by a rapid decrease in weight and aggravation of all the symptoms. No further doses were given, and, although she improved slightly in weight, her condition was very bad when the experiment terminated.

In this case, therefore, the extracted oil was insufficient to give a good effect, if it did not actually do harm.

(3.) *Feeding on a Fish-meal Diet.*—A special fish diet was made up so as to resemble diet 8 in its proportions of protein, fat, &c., by substituting fish-meal for part of the lard and all of the casein. It consisted of fish-powder, 90 grm.; lard, 25 grm.; Marmite, 12 grm.; salts, 12 grm.; starch, 159 grm. It was made up with water in the usual way, and divided into a certain number of equal-sized rations. Assuming that a rat ate 10 grm. of the fish diet, it would receive about 0·6 grm. of the fish-fat. Litter K, consisting of four does, was used, and the results are shown in the curves on chart 2, last two curves. Owing, no doubt, to the liberal food-supply they received before weaning, they persisted in growing, although at a slow rate, for ten weeks after weaning. Eye symptoms did not occur in any, but from the experience obtained from the other litters it can be said that if the diet contained sufficient vitamin A the weights would have increased rapidly. Two of the does were given a mixture of equal parts of fish diet and diet 8, so that their dose of oil was the same as in the case of those rats that received the fish-powder in addition to diet 8—viz., 0·3 grm. As shown on the chart, this did not cause any distinct difference, and we may assume in this case also that 0·3 grm. does not contain appreciable quantities of vitamin A. Another litter, M, was fed partly on diet 8 + cod-liver oil, partly on full-strength fish diet, and some on diet 8 alone. The growth in the first two of these groups was maximal, but, unfortunately, some of the controls showed that the litter had, like K, been too well fed before weaning, or weaned too late, for they showed considerable powers of growth. Thus the average gain per rat for three weeks was 41 grm. on cod-liver oil, 46 grm. on the fish diet, and 23 grm. on diet 8 alone. These results are in marked contrast to the cases where ethereal extract was used.

Oyster-oil.

This was prepared as follows: Twenty-five Stewart Island oysters were strained, minced, and extracted several times with strong alcohol at room-temperature. The alcohol was distilled off in a partial vacuum at a temperature under 50° C. The residue, as well as the residue of oyster-flesh, was extracted by shaking up with ether several times and drawing off the ethereal extract. This was then washed with boiled water in a separating-funnel, and the oil was obtained by allowing the ether to evaporate. In

all these manipulations care was taken to avoid oxidation, but it was not possible to use elaborate precautions.

The oil was administered to two rats, B_2 and B_3, that had developed symptoms of lack of vitamin A. Unfortunately, they were first used for a class demonstration to show that cod-liver oil was curative, and distinct improvement had set in before the oyster-oil treatment was begun. On continuing with oyster-oil, given into the mouth as a smear on the end of a glass rod because it was too viscid for the pipette, their condition became much worse. Their eyes had recovered, but their coats were staring, the skin around their genitals was wet and discoloured, the buck developed a painful condition of the penis, and altogether they were so miserable that mutton-bird oil was substituted for the oyster-oil. In a few days there was a marked improvement in their whole appearance, and the weights rose steadily.

Another attempt to use this oil was made on E_3 (chart 2). She had shown a marked growth and recovery from avitaminosis under the influence of cod-liver oil, but about the 26th December, six weeks after the oil had been stopped, her weight began to fall and slight eye symptoms came on. From the 31st December to the 6th January she was given a daily dose of 0·06 grm. of the oyster-oil, diluted, for easy administration, with olive-oil. In spite of this her weight continued to decrease and the eyes became deeply affected.

These experiments, therefore, give no evidence of vitamin A in ethereal extract of oysters.

Red Cod (Lotella bacchus).

A few observations were made on the flesh-oil and liver-oil of the red cod, extracted in each case with ether in a Soxhlet apparatus. The oils were administered to rats that had previously been the subjects of other experiments and were in very poor condition (see curve of E_4, chart 2, R.C.L.O., on 28th December). No amelioration of the symptoms resulted, and although the conditions of experiment were such that one can hardly speak dogmatically, yet the impression received was that here also ethereal extracts were useless, if not actually harmful.

Conclusions.

1. Mutton-bird oil is one of the richest known natural sources of vitamin A. Daily doses of 0·04 grm. contain sufficient of it for the normal growth of rats; in some 0·02 grm., and in still others 0·01 grm., was found to cure xerophthalmia and cause some growth.

2. The vitamin A of mutton-bird oil does not appear to be stored to the same extent as that of cod-liver oil or butter, and vitamin B appears to be absent.

3. In the New Zealand fish examined (tarakihi) the fat of the flesh was not particularly rich in vitamin A—thus at least 0·3 grm. fat was necessary for maintenance or growth. It is suggested that there are probably considerable differences in the vitamin content of the fat of fish-flesh, depending on the food of the fish.

4. The ethereal extracts of tarakihi flesh, oysters, red cod (flesh and liver) were not found to contain vitamin A, and when given to animals suffering from avitaminosis seemed to aggravate the condition.

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Popular Names of New Zealand Plants.

By JOHANNES C. ANDERSEN, F.N.Z.Inst.

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THE number and diversity of the popular names of our New Zealand plants are made more evident when these popular or common names are gathered together and placed side by side. Their heterogeneous nature is no doubt largely due to the partial isolation of the various early settlements of the Islands in the midst of a new, vigorous flora, and also to the innate independence or obstinacy of thought that will often induce a man to give a new name even where one already exists.

The names of a few of the plants were well known from the works of Cook and other explorers; but there was a very great number quite unfamiliar to the settler, and to such of these as brought themselves under his notice, either through their use or the reverse, he set about giving names, or adopting or corrupting such Maori names as he could learn or would tolerate.

There are many reasons influencing the choice of a name:—

(1.) The name chosen may describe the plant as a whole or characteristic parts of it: broadleaf, whitewood, bluebell.

(2.) It may refer to its use medicinally: scurvy-grass, Maori painkiller.

(3.) It may refer to its use as food: cabbage-tree, tea-tree, Maori cabbage.

(4.) It may refer to its similarity to some other object: lacebark, lemonwood, turpentine-tree.

(5.) It may refer to its similarity in a humorous aspect: Captain Cook's ropes, vegetable boa-constrictor.

(6.) It may refer to its similarity to some other familiar plant: New Zealand oak, New Zealand ash, New Zealand teak.

(7.) It may refer to its habitat: bog-lily, mountain-ribbonwood, sand-gunnera.

(8.) It may be altogether fantastic: wild-irishman, spaniard or bloody spaniard, bush-lawyer.

Curious contradictions occur at times. For instance, *Pteris tremula*, besides being known as the "trembling fern," is known as the "scented fern" and the "stinking fern." Whilst the latter names appear anomalous, both have their justification; for Field remarks, "It . . . may be at once distinguished by the strong aromatic odour, something like camomile, which its foliage emits when bruised. In the summer-time, surveyors cutting lines through the warm sheltered gullies in which it abounds often find the smell so strong as to be unpleasant, and I have heard it called the 'stinking fern' on this account, though many people rather like the scent." (Field, *Ferns of N.Z.*, p. 90.) Again, it is difficult to understand why the broadleaf was so called. There are plants with leaves much broader, and it is evidence of the persistence of a name, however seemingly inappropriate, that this is now the universally known name for *Griselinia littoralis*.

The manner in which different people are influenced by different parts of the same plant is well illustrated in the various names given to *Coprosma lucida*—broadleaf, orange-leaf, shining coprosma, coffee-tree, yellow-wood

The names in the category 2 (medicinal) above were originally the chief of the names given, since the study of plants was wholly from a medicinal point of view. Innumerable names remain as evidence of this—self-heal, wart-weed, fever-few, &c.; and the evil days that have overtaken the herbal science are shown by the very few names now given because of supposed medicinal properties.

The name "cabbage-tree" was given by Captain Cook's people. The following remarks appear in the Journal of 10th October, 1774: "These cabbage-trees or palms were not thicker than a man's leg, and from ten to twenty feet high. They are of the same genus with the cocoa-nut tree; like it they have large pinnated leaves, and are the same sort as the second sort found in the northern parts of New South Wales [*vide* Hawksworth, *Voyages*, vol. 3]. The cabbage is, properly speaking, the bud of the tree; each tree producing but one cabbage, which is at the crown, where the leaves spring out, and is enclosed in the stem. The cutting off the cabbage effectually destroys the tree; so that no more than one can be had from the same stem. The cocoa-nut tree, and some others of the palm kind, produce cabbage as well as these. The vegetable is not only wholesome, but exceedingly palatable, and proved the most agreeable repast we had had for some time." (Cook, *Voyage to Pacific Ocean*, 1777, vol. 2, pp. 148–49.)

The remarks that the leaves are pinnate, that each tree produces but one cabbage, and that the cutting of it destroys the tree, lead one to suspect that the tree referred to is not a *Cordyline*. The entry in the Journal was made at Norfolk Island, not New Zealand, but there is no indication in Cook as to what tree is referred to. Even the botanist Forster gives no help. In speaking of the vegetation of Norfolk Island he says, "The productions of New Zealand were here united to those of New Caledonia and the New Hebrides; for the cypress of the one, and the cabbage palm which we had seen in the latter, flourished here in the greatest perfection. It was chiefly on these two species, that we bestowed our attention; the former supplied the carpenter with several spare brooms, and pieces of timber; and the latter offered us a most welcome and palatable refreshment. We cut down several of them, and took on board the central shoot, or heart, which in taste more resembles an almond than a cabbage." (George Forster, *A Voyage round the World*, 1772–75, Lond., 1777, vol. 2, pp. 345–46.) In his *Plantis esculentis Insularum Oceani Australis*, 1786, he includes *Cordyline* (as *Dracaena*) and *Rhopalostylis* (as *Areca*), and says of *Areca sapida* (p. 66), "Reperitur spontanea in nova Zeelandia usque ad aestuarium Charlottae reginae, et frequens in Norfolciae insula deserta. Huius praecipue Cor sive Caput in deliciis est apud nautas Europaeos, et cum oleo et aceto parari solet." There is a more definite clue in Banks (*Journal of the Right Hon. Sir Joseph Banks . . . during Captain Cook's First Voyage . . .* 1768–71, Lond., 1896, p. 227), where he writes of New Zealand plants, "We also once or twice met with a herb like that which the country people in England call 'lamb's-quarters' or 'fat-hen,' which we boiled instead of greens; and once only a cabbage-tree, the cabbage of which made us one delicious meal . . . ." A footnote identifies the former as *Atriplex patula* Linn., identical with the English fat-hen, and the latter as *Areca sapida* Soland., of which Hooker gives the range (*Handbook of the*

New Zealand Flora, 1867, p. 288)—" Northern and Middle Islands; as far south as Queen Charlotte's Sound, *Banks and Solander*, &c. Very closely related to the Norfolk Island *A. Baueri*, which is a larger plant. Young inflorescence eaten." He says nothing of the eating of the young shoots of the *Cordyline*.

It would appear, then, that primarily the term "cabbage-tree" or "cabbage-palm" was applied to *Areca Baueri*, but has become transferred exclusively to *Cordyline*. In one place there is the remark, " We also found one cabbage-tree which we cut down for the cabbages" Cook's First Voyage, 1768–71, in Hawksworth, vol. 2, p. 322). This entry is on 29th October, 1769, when Cook was at Tolaga Bay, and seems to refer to *Cordyline;* in Cook's own Journal, however, the last word of the quotation is " cabbage," not " cabbages."

Both *Cordyline* and *Rhopalostylis* (*Areca*) were found by Cook in Norfolk Island; if the hearts of both were not eaten as cabbage there, they apparently were in New Zealand; and it was possibly the much more common occurrence of *Cordyline* in these islands that caused the name "cabbage-tree" to be transferred exclusively to that species. Colenso (*Trans. N.Z. Inst.*, vol. 1, ed. 1, p. 32 of his Essay, " On the Botany . . . of the New Zealand Group), when writing of the fruits and trees used as vegetables, says: " The young inner blanched leaves and heart of the Ti, or "Cabbage-tree" (*Cordyline australis*), and of the Nikau, or New Zealand Palm (*Areca sapida*), were eaten both raw and cooked." I have seen a long row of *Cordyline* in a public garden struggling to grow beyond the reach of schoolboys, who persisted in pulling the young central shoots, eating them with relish.

One would suppose that Kirk had forgotten the origin of the name when he says, " Settlers and bushmen generally apply the unmeaning name of 'cabbage-tree.'" (Kirk, *Forest Flora of N.Z.*, p. 295.) Cheeseman, too, says, " Universally known to New Zealand residents by the inappropriate name of 'cabbage-tree'" (Cheeseman, *Manual of N.Z. Flora*, p. 707). Thomas explains the name, and errs in doing so: " It receives its name from the arrangement of its leaves in tufts or heads at the ends of the branches" (Clark, *A Southern Cross Fairy-tale*, p. 53). Butler remarks, " The cabbage-tree or ti-palm is not a true palm, though it looks like one. It has not the least resemblance to a cabbage." The settlers and bushmen followed Cook in using the young heart as a vegetable, and in their naming of the tree; and when the reason for the name is known its inappropriateness disappears. To one section of the public it will always be the cabbage-tree; to the other section, let it be lily-palm. " Ti-tree" and " ti-palm" should certainly be banned, because of the hopeless confusion with tea-tree. Froude, in *Oceana*, constantly writes " ti-tree" when he refers to manuka scrub (tea-tree); and Cockayne notes a worse confusion in the naming of a railway-station Ti-tri (Cockayne, *N.Z. Plants and their Story*).

Tea-tree, too, is a name that has come through Cook's people. Manuka-leaves were used for tea during his first visit, when the name " tea plant" was given. The plant is described and figured, and Cook writes in May, 1773, " The leaves, as I have already observed, were used by many of us as tea, which has a very agreeable bitter, and flavour, when they are recent, but loses some of both when they are dried. When the infusion was made strong, it proved emetic to some in the same manner as green tea." (Cook, *Voyage towards the South Pole*, 1779, vol. 1, p. 101; *illus.*, p. 100.)

From the leaves of the rimu Cook brewed "spruce beer," and the black-pine furnishes a beverage known to bushmen as "pine-beer." The tree containing beer may usually be known by a black, smutty-looking stain that extends some way up the trunk; and if a hole be bored at the base the tree may be plugged and tapped like a barrel.

In the names of categories 4 and 5 (similarity to other objects) observation and imagination play a prominent part, and many pleasing names result. Ribbonwood, lacebark, and thousand-jacket, are most appropriate names, all applied to *Gaya*, *Hoheria*, and *Plagianthus*. Lemonwood is a good name for *Pittosporum eugenioides*, though the property is more obviously in the leaves than in the wood. The young leaves, when bruised between the fingers, emit a very agreeable fragrance resembling lemon. A scent was in the sap, for it was from this tree, the *tarata*, that the Maori gathered gum which he used for manufacturing a favourite perfume. He made incisions in the bark, and gathered the congealed drops on their oozing through.

The names of category 6 (similarity to other plants) show some observation, though little imagination. A number of these names persist—as "New Zealand holly," for *Olearia ilicifolia*; "New Zealand teak," for *Vitex lucens*. Many of them have been disused, the similarity proving too superficial for adoption and perpetuation of the name. There is a name of this kind lately given—"New Zealand hawthorn"—to *Carpodetus serratus*, one of our most graceful and beautiful flowering trees, and a true New-Zealander, which Dr. Cockayne, in *The Cultivation of New Zealand Plants* (p. 109), commends as suitable for adoption as the national flower. This tree is not in the least like the hawthorn—in shape, foliage, colour or texture of bark, ramification, or fruit. The sole resemblance is in the flower, and in the appearance of the clustered flower only; scent and colour differ from the hawthorn. Moreover, this very name was given to the English tree to signify the thorn that bears a haw; and *Carpodetus* has neither haw nor thorn. *Carpodetus* itself is an attractive name: why should it not be adopted? Or why not adopt the Maori name, *putaputaweta*, or the recorded shorter form *punaweta*? Or, seeing that the point of resemblance is in the flower, and that the flower of the hawthorn is known as "may," why not "Maori may"? *Carpodetus* much more closely resembles the silver birch, in general shape of the tree, shape and suspension of leaf, ramification, colour and texture of the bark—resemblances visible all the year round. "Maori silver birch" would be a much more appropriate name, were it not for the fact that there is already a name "silver beech," and that the name "birch" has become anathema. The name "New Zealand hawthorn" might more appropriately be given to the already irrevocably named wild-irishman, or scented thorn, or matagowry, whose leafless winter appearance is very like the lifeless appearance of the dry twisted hawthorn as seen in a hedge; and the scented white flower in spring gives one a leap of pleasure as does the hawthorn, with its "white sheet blanching on the hedge."

The word "native" has been prefixed to almost as many names as the words "New Zealand"—native aniseed, native convolvulus, &c. This word may perhaps be descriptive if used within New Zealand and between New-Zealanders; but if used outside—say, in Australia—its meaning will be quite changed; for should the New-Zealander speak of the "native teak," the Australian would think not of a New Zealand but of an Australian tree. The confusion might be avoided were the word "Maori" used instead of "native," and, indeed, instead of the long doublet "New Zealand." There

is "Maori cabbage," "Maori onion"—why not "Maori aniseed," "Maori convolvulus," &c.?

The names of category 8 (fantastic names) show the imagination running riot; they seem appropriate, though often it is impossible to give any definite reason for the name. No trace has been found of any reason for the name "wild-irishman" as applied to *Discaria toumatou.* Many old settlers have been questioned without result, or with such barren result as the following: One, being asked, "Why was the wild-irishman called the wild-irishman?" answered, "I suppose because it is *like* a wild Irishman." "What characteristics have they in common?" "Well. I—I—I really can't say." And so it is; it is a name that every one understands, but no one can explain. Whilst it is often written with a capital, "Irishman," it is now as often written with a small letter, "irishman"; and when it is the plant that is referred to the small letter should be used, leaving the form "wild Irishman" to signify the Sinn-Feiner. The same remark applies to the name for *Aciphylla*—"spaniard"—another name of unexplained origin. There seems even less connection between the human Spaniard and the vegetable spaniard than between the human wild Irishman and the vegetable wild-irishman; and the conjectured corruption "spine-yard," whilst improbable, is no more improbable than the fabled "Bill's-yard" as the origin of "billiard." The name "missionary-plant," given by the Maori to the sweet-brier (Boyd, *Our Stolen Summer*, p. 77), does not come into this category, as the humour of it, more readily perceived, perhaps, by the agriculturist or pastoralist, was not intentional: it was so named as it was brought, for dear association' sake, by the homesick wife of a missionary.

Many of the names show considerable gifts of observation, imagination, and ingenuity: there are others that show the namers to have been almost destitute of all three. Kirk in 1875 remarked: " . . . the term 'birch' may be regarded as a generic name applied by bushmen to any small-leaved tree, and qualified by the prefixes 'black,' 'white,' or 'red,' at the caprice of the individual, or as may be suggested by the colour of the foliage, bark, or timber." (*Reports on the Durability of N.Z. Timber*, 1875, p. 16.) So the term "black birch" was in many districts applied to *Pittosporum tenuifolium*, and to *Weinmannia racemosa* in Otago—the latter tree being also known as "brown birch" and "red birch." *Myrsine Urvillei* was known as "red birch," and *Carpodetus serratus* and *Quintinia serrata* as "white birch." It was principally to trees of the species *Nothofagus* (then known as *Fagus*) that the term "birch" was applied, and a distinguishing of the various kinds by the prefixing of a descriptive word was a step in the right direction; but in this instance the step was on a path that led to a quagmire. To take only the instance of *Nothofagus Solandri* (formerly *Fagus Solandri*): this was known as "black" birch in the Wellington district; "black," "white," "red," and "brown" birch in Canterbury; "white" birch in Nelson; "white," "black," and "black-heart" birch in Otago. "In the Oxford Bush" (Canterbury), says Kirk, "I learned that the tree [*N. Solandri*] was termed 'red birch,' 'brown birch,' 'white birch,' 'black birch,' and 'yellow birch' at different stages of its growth, but the application of these terms varied greatly; perhaps 'black birch' was most generally applied to the mature condition before decay commenced, and 'white birch' to the young state; but there were too many exceptions to allow of the names being other than misleading."

The confusion created has been endless; it has at times even resulted in commercial loss; yet so strong is habit that confusion was preferred before a change of name. And, indeed, the bushmen might well ask what name they should adopt; for the scientists came and added to the confusion by pointing out that the trees usually called "birch" were not birch at all, but beech—when a fresh crop of names resulted: "black beech," "red beech," "dusky beech," &c. The scientists themselves, however, in calling the species *Nothofagus* "beech," took care—that is, *usually* took care—to make the distinguishing prefix one that would not lead to a repetition of the old confusion. *N. Solanderi* was accordingly called "entire-leaved beech"; *N. cliffortioides*, "mountain beech"; *N. Menziesii*, "round-leaved beech"; *N. fusca*, "tooth-leaved beech." It was some time before even these names were agreed upon; and "silver beech" finally took the place of "round-leaved beech" for *N. Menziesii*. A note may here be made of the fact that, whilst the entire-leaved beech was *Fagus Solandri*, on *Fagus* being changed to *Nothofagus*, *Solandri* was altered to *Solanderi;* but this has been altered back again to *Solandri*, for that was the original and not incorrect spelling of the word.

Again, these common, unimaginative names may take a double form—"tree-nettle" and "nettle-tree"; "tree-fuchsia" and "fuchsia-tree"; "tree-grass" and "grass-tree." The form taken depends upon the name-giver thinking, say, of the fuchsia, "This tree is like a fuchsia"—whence "fuchsia-tree"; or "This fuchsia is like a tree"—whence "tree-fuchsia." "Fuchsia" and "tree" become the descriptive part of the name according to the thought perceiving the plant as a tree or a fuchsia. Were the names to be retained, therefore, the correct form would be "tree-nettle," "tree-fuchsia," seeing that the plants are primarily nettle and fuchsia, and secondarily tree-like. Of the names "tree-grass" and "grass-tree" as applied to *Cordyline*, however, "grass-tree" would be the correct form, seeing that this plant is tree primarily, and grass-like secondarily. When Dr. Cockayne called *Olearia* sp. "daisy-tree" he used the correct form. In the second edition of *New Zealand Plants and their Story*, however, he changed it to "tree-daisy," bringing it into line with other similar compounds—"tree-coprosma," "tree-fuchsia," "tree-heath," "tree-moss," "tree-lupin," &c.—all of which are correct; for in these instances the plants are larger in growth than ordinary—so large that in comparison with related forms they seem tree-like. The *Olearia*, however, is not a daisy of such giant growth that it is like a tree, but a tree that bears flowers like daisies; it is, in fact, a tree that reminds one of a daisy—not a daisy that reminds one of a tree. He calls the false mountain-holly (*O. macrodonta*) a "tree-daisy"; but had this plant been like a daisy that had grown as big as a tree it would never have been called a holly: the tree is holly-like in general appearance, daisy-like in the flower; and what is meant when it is said that the false mountain-holly is a daisy-tree is that it is a holly-like tree with a daisy-like flower. "Cabbage-tree" has not been changed to "tree-cabbage," and rightly; nor should "daisy-tree" have been changed to "tree-daisy." The name "palm-lily," again, should be "lily-palm"; for primarily the tree is, in resemblance at least, a palm: it is a palm with lily-like flower. To the casual observer—and that means the usual observer—the tree is more like a palm than the flower is like a lily. One authority is quoted for the form "lily-palm."

These compound names, too, show a curious tendency towards coalescence. This is revealed in writing and printing; their coalescence

there reveals the coalescence in the thought. They start as two words, then the two words are hyphened, and finally the hyphen is dropped, the two being then written and pronounced as one word—broad leaf, broad-leaf, broadleaf. When this takes place there is a subtle change of accent, more or less marked. As two words, each word has its own accent: as a compound the first word retains its accent, but the accent on the second is subdued or suppressed. Many New Zealand names occur in the three forms—blue bell, blue-bell, bluebell; duck weed, duck-weed, duckweed; supple jack, supple-jack, supplejack; lace bark, lace-bark, lacebark; &c. The distinction in the accent is clearly heard if we say aloud, "The bluebell has a white or blue bell; and its blue bell caused it to be called the bluebell." Occasionally three words are connected, or even four: forget-me-not, love-in-a-mist. I have seen as many as six—"Jack-go-to-sleep-at-noon," or "Jack-go-to-bed-at-noon," for *Ornithogalum umbellatum* and *Tragopogon pratensis*. The hyphens have not yet been dropped, and tha names probably do not occur in literature as forgetmenot and loveinamist. Forget-me-not is printed as one word in German—*vergissmeinnicht*. Whilst the hyphening and compounding may be, and probably is, in large measure due to the writers, it is possible that in many instances they are due to the printer, or at least to the publisher's reader. A good reader will decide upon a certain course, consistent as may be maintained, and writers may find a difficulty in throwing him off that course; or they may be indifferent, which furnishes the reader with his justification.

There are certain words that have long resisted the hyphening tendency. The words "white pine," "black pine," &c., have from the beginning appeared as two words. In writing of, say, the last fifteen years, however, the forms "black-pine," "white-pine," "silver-pine," "silver-beech," &c., have become common. The hyphening of these seems to date from about 1905, and is now the rule rather than the exception. This remark, however, needs some modification; for a great number of the papers and books from which the hyphened words have been gathered are the work of one writer, Dr. Cockayne. But there is this to be said: When a leading writer, and a writer of authority, uses names in a certain form, his lead is almost sure to be followed; so that his introduction of hyphening will go a long way towards establishing the custom—the more so since his writing covers the whole New Zealand botanical field so thoroughly. As far back as 1889, however, the most unusual forms "blackpine" and "blackmaire" appear; but since these are given as English names in a French work—*Fleurs sauvages et bois precieux de la Nouvelle-Zélande*, by Mrs. Hetley and M. Raoul—they can hardly be taken as indicating a tendency in the English language, though certainly they do indicate a general linguistic tendency. At first the names look strangely and startlingly unusual; but the strangeness soon wears off; and, as the hyphen is perhaps no more than the indication that two words are in process of becoming a compound word, "blackpine" should naturally follow from "black pine" and "black-pine." "Black-moor" of "Paradise Regained" (iv, 72) is now "blackamoor." In the opening of "The Cherrie and the Slae" Montgomery has "with gallant gold-spinks gay"; but Bewick prints the word "goldspink"; and "goldfinch" is now always one word. It cannot be said, however, that it will always be one word; for even the long-familiar name "blackbird" appears occasionally as two unhyphened words, "black bird." In *My New Zealand Garden*, 1902, p. 74, it occurs as two words twice on one page, whilst "goldfinch" occurs on the same page as one word.

Uncensored writing and printing furnish curious evidence of the working of the human mind: some minds seem to need no hyphens in compound words; others seem to require them as cautious alpine climbers require a rope. Moreover, there is change in the habits even of the habitual writer. In the first edition of the well-known *New Zealand Plants and their Story* the words "bracken fern" are used early in the book: seventy pages on they are hyphened, "bracken-fern"; had the book been half as long again we may have had the form "brackenfern." Again, in the same book the hyphened "candle-nut" proceeds to "candlenut," and "willow-herb" to "willowherb." Again, the sea-side brome grass" of Buchanan (? Kirk) becomes the "seaside brome-grass" of Cockayne.

Is there any danger of words with two descriptive prefixes becoming one word — for instance, "yellow silver pine"? It already has one hyphen, and there is a form "yellow-pine," so "yellow-silver-pine" is not impossible: is "yellowsilverpine"? It is almost to be hoped that it is not possible, or we may fall in the rugged way of Teutonic agglutination. The appropriate but little-used "wait-a-bit" is not in this category, as it is a name, not merely a description. The name "paper-mulberry-tree" of Mueller is in the category, and in it the second hyphen at least seems unnecessary. If the oak be also called "tree" it is not "oak-tree," but "oak tree": the hyphen adds nothing to the meaning, nor does it remove any ambiguity. The name "forget-me-not" as a flower is practically one word, yet it loses nothing of its homogeneity if printed as Armstrong prints it, without hyphens, "forget me not," for it is the expression of a desire, as well as a flower.

The hyphening tendency, and the following agglutination, appear, however, to be natural tendencies, betraying a species of Teutonic outcrop in our flexible, composite language; and their appearance is by no means confined to botanists or scientists. The word "castiron" appeared in the local *Dominion* newspaper in June, 1919; whilst the Oxford University Press *Rules for Compositors and Readers* includes "cast iron" in a list of compound words that should be printed without the hyphen. In the first editions of Tennyson's poems the following compounds appear, amongst others: In "The Lady of Shalott, 1833—yellowleavèd, greensheathèd, overtrailed, silkensailed, pearlgarland, barleysheaves, thickjewelled; and in "Mariana," 1830—casementcurtain and marishmosses. In the *Collected Poems* of 1851, both "yellowleavèd" and "greensheathèd," which appeared in stanza 1, were dropped in the remodelling of that stanza; "overtrailed" and "silkensailed" became "barges trail'd" and "silken-sail'd"; the "pearlgarland" was dropped altogether; "barleysheaves" became two words—"barley sheaves"; "thickjewelled" and others were hyphened—"thick-jewell'd." The two compounds from "Mariana" were also hyphened, and so they have remained. Tennyson himself, speaking of the word "tendriltwine" in *Poems by Two Brothers*, says, "I had an absurd antipathy to hyphens, and put two words together as one word." His antipathy had been conquered, apparently, by 1851. In "The Lady of Shalott," however, appear the compounds "village-churls," "market-girls," "bower-eaves," "saddle-leather"; these remain in 1851, all but "market-girls," where the hyphen is dropped—"market girls"—and this distinction still remains. Whilst the poet is not quite consistent in his practice, it is evident he perceived and followed a principle; and so with others—there is a perceptible drift towards the hyphening or agglutination, especially of words of one syllable. At the same time there is apparent

a resistance to the drift, so that words that look and sound as though they might well coalesce, break again even if they coalesce for a time—as though these were a more or less definite size natural to the idea-crystals, at least in English.

The reason for the coalescence appears to be this: The prefixed word, whilst at first merely descriptive, gradually comes to be regarded as part of the word; and as a matter of fact it is part of the word. Take the familiar name "blackbird." It is evident that the original name-givers recognized this songster simply as a black bird. There were doubtless many other black birds, but this one attracted attention so much, to the exclusion of others, that it became *the* black bird, the two names joining, with the idea, as one—"blackbird." So it is with other compound names: once the prefixed word comes to be regarded as actually part of the name—when word and description are one in thought—coalescence takes place. There is no whitebird, though there are white birds; there is a whitethroat, however; a blackcap; a redpoll; and so on. There appears to be no necessity for hyphening the prefixed descriptive word unless the compound word resulting differs in meaning from the unhyphened words. If the descriptive word be a substantive there seems to be more logic in inserting the hyphen, though the example given by the American writer on this subject, F. Horace Teall, does not cover all instances. He points out that "paper box" means a box made of paper, whereas "paper-box" means a box for holding paper. When *Paratrophis* was called the "milk-tree," however, the name merely meant "the tree with milk-like sap," and that is the meaning that would almost certainly be assumed by any one first seeing the name. Omission of the hyphen would not change the meaning to "the tree made of milk," and "milk tree" is as clear in meaning as "milk-tree." Milk is one substance, however, and tree is another; and when both are used as one name there seems to be some natural tendency to join them with a hyphen and make them one word. In the instance "oak tree," oak is already a tree, and does not need the second word at all, nor would the coalescence of the words change the meaning in any degree. On further descriptive words being prefixed to "milk-tree," as in "large-leaved milk-tree," a second hyphen is required to join the two descriptive words. If it were intended to say that the milk-tree was a large tree with leaves, then "large leaved milk-tree" would be sufficient; but in this instance the "large" refers to the leaf and not to the tree. "Silver pine" does not mean a pine made of silver, any more than "milk tree" means "tree made of milk." The debatable ground appears when the question arises as to whether "silver" is a substantive or an adjective; if an adjective, there is no need for the hyphen between it and the substantive following: that is, adjective is hyphened to adjective, substantive to substantive—"golden-haired," but "golden hair." Thus the forms "cranesbill" and "parrotsbill" are better than "crane's bill" and "parrot's bill." The latter may refer to the actual bill of a crane or a parrot; the former has quite another significance An illustrative example is the name "hanging-tree spleenwort" given by Potts to *Asplenium flaccidum*. The hyphening is here incorrect. As at present, it means the spleenwort growing on the hanging-tree, whereas it was intended to mean the hanging spleenwort which grows on a tree. The form should therefore be "hanging tree-spleenwort."

All statements must, however, be made with caution, for refutation may be met on every hand. Should the forms be "yellow wood" and

"white wood," or "yellow-wood" (yellowwood) and "white-wood" (whitewood)? The latter seem preferable, if only for the reason that "yellow wood" and "white wood" may mean wood that is yellow or white. "Yellowwood," again, seems to offer an objection in the doubled *w*, and the hyphen is usually present in words like "yellow-wort," "yellow-weed," "mallow-wort"; but "chaffinch" had at first to contend with a tripled consonant "chaff-finch": it simply ignored one of them, and a *w* might similarly be ignored—"yellowood" if two seem objectionable—"yellowwood."

In passing, two recent names of this kind may receive a moment's attention—"red tea-tree" and "white tea-tree," given, on account of the colour of their wood, to *Leptospermum scoparium* and *L. ericoides* respectively. As however, there are red- and white-flowering manuka, and the flowers are far more evident to the ordinary observer than the cut wood, it is inevitable that it will be supposed that the names were given because of the flowers, and confusion must follow. It would be better to nip these names in the bud.

The whole argument regarding the hyphening or otherwise of words seems to become unnecessary, and to collapse when it is remembered that in speech there is no indication, or no certain indication, of the presence or absence of a hyphen. The slight difference in accent between "black bird" and "blackbird" is too slight to be relied on; and, moreover, accent varies with individuals, and even with mood. Yet the fact that one compound may appear objectionable when written, and another unobjectionable, shows that there is a linking-up in the thought, even if unconscious; and and it is this mental linking-up that affects the pronunciation. Confusion is less likely to occur in writing than in speaking, and in the written sentence the context will show if the words "black cap" are to be taken as the bird or as the cap that is black.

F. Horace Teall, already mentioned, has attempted the formulation of rules for the compounding of English words; but the rules arrived at are altogether too complex, and also appear incapable of application. He gives a long list of phrases or words which should not be joined, and a list of words which should not be separated. In the following, a few of the former are given in the first column, a few of the latter in the second:—

Black bryony	Blackbird
Black currant	Blackcap
Black pine	Blackthorn
Blue grass	Blueweed
Green linnet	Greenbird
Red birch	Redbud
Red cedar	Redcap
Red pine	Redwood
White ash	Whiteear
White pine	Whitethorn
Wild oat	Wildcat
Yellow pine	Yellowweed

There appears to be no reason, other than usage, for one form more than the other; and if usage be urged as the reason for the difference, then the rule is usage—a rule that cannot possibly be set down. It is true that in one case the second word is more particular, in the other more general; "pine" is a particular class, as "red pine," but "wood" is a general term, so "redwood." "Grass" is a particular class, so "blue grass," whilst "weed" is general, so "blueweed." Yet we have the form "black-pine";

and in speaking of "Kentucky blue grass," does not the decided accent on the "blue" as compared with the light accent on the "grass," together with the shortening of the pause between the two words, show that in thought the words are coalesced—"blue-grass" if not "bluegrass"? Then if "greenbird" to distinguish it from the general class of green birds, why not "greenlinnet" to distinguish it from other linnets? "Goldfinch" and "chaffinch" might be quoted to illustrate the coalescence; but it might then be pointed out that these are two substantives, not adjective and substantive. Teall complains that the makers of dictionaries apparently make no attempt to use the hyphen according to some definite rule. He is right: no attempt is made, and the reason is given by the editors of the *Concise Oxford Dictionary*, 1911. "We have also to admit," they write, "that after trying hard at an early stage to arrive at some principle that should teach us when to separate, when to hyphen, and when to unite the parts of compound words, we had to abandon the attempt as hopeless, and welter in the prevailing chaos." Not all dictionary-makers are so pessimistic, however; and in the 1923 edition of Funk and Wagnall's *New Standard Dictionary* F. Horace Teall has made the heroic attempt to maintain a consistent system of hyphening through the two big volumes.

In the Oxford University Press *Rules for Compositors*, 1912, referred to above, an attempt has been made to formulate a few rules that may guide, if they cannot direct and control:—

"The hyphen need not, as a rule, be used to join an adverb to the adjective which it qualifies: as in—a beautifully furnished house: a well calculated scheme. When the word might not at once be recognized as an adverb, use the hyphen: as—a well-known statesman; the best-known proverb; a good-sized room; a new-found country.

"When an adverb qualifies a predicate, the hyphen *should not* be used: as—this fact is well known.

"Where either (1) a noun and adjective or participle, or (2) an adjective and noun, in combination, are used as a compound adjective, the hyphen *should* be used: a poverty-stricken family; a blood-red hand; a nineteenth-century invention.

"A compound noun which has *but one accent*, and from familiar use has become one word, requires no hyphen: bla'ckbird; hai'rbrush; ha'ndbook; ma'ntelpiece; scho'olboy; whe'elbarrow.

"Compound words of *more than one accent*, as a'pple-tre'e, che'rry-pie', gra'vel-wa'lk, as well as others which follow, require hyphens: air-man; arm-chair; death-rate; farm-house; hour-glass; jaw-bone; new-built; race-course."

Thus far the rules may be followed, since they appear formulated on some comprehensible reason, though the words last quoted seem to be in a half-way condition; for surely no hyphen is needed in airman, farmhouse, hourglass, jawbone, racecourse. The last rule, however, appears rather to be an arbitrary instruction; for after saying that "half an inch," "half a dozen," &c., require no hyphen, it is added: "Print the following also without hyphens: cast iron; court martial; easy chair; high road; plum pudding; post office." It has been objected that whilst no hyphen is needed in "jawbone" considered by itself, yet it is found convenient to compound it as one of a large category of similar expressions, some of which would not make good consolidated words, as "arm-bone," "leg-bone," "thigh-bone," &c. Yet it is a matter of custom; for "jawbone" and "backbone" do not come amiss, and why should "armbone" and "legbone"?

This paper was written before these *Rules for Compositors* were seen, and the writer was gratified to find himself so much in accord with the Rules; but this last instruction seems to flout the rules themselves, and it will not be observed. "Highway" is an accepted form—why not "high-road" or even "highroad"? The latter is used, and, as noted above, "castiron" has been used. "Court-martial," too, follows rule, as do "plum-pudding" and "post-office." In speech, one can only tell uncertainly from the accent if the speaker conceives of the compound as one word or two.

The Maori was a prolific name-giver; and his names show him to have been possessed of a keen sense of discrimination, so that many of those names may be adopted without fear of confusion, and more are being adopted from year to year. In his new edition of *New Zealand Plants and their Story*, Dr. Cockayne has finally adopted "rimu," "matai," "kahikatea," instead of the English "red," "black," and "white" pine. He has adopted "koromiko" in place of "veronica"—an adoption that will help to keep in mind the distinction between the English and New Zealand forms of veronica. Like the bushman, though not to the same extent, the Maori was puzzled by the various species of beech, and Kirk excepts his beech-names when recommending the adoption of Maori names generally. "In the great majority of cases," says he, "the Maori names are much better adapted for commercial use than those commonly employed" (Kirk, *Forest Flora of N.Z.*, Pref., p. vi). There is now no attempt made to supplant such names as "kauri," "totara," "pukatea," "karaka," "ngaio," "tawa"—partly because the distinctiveness of the trees made adoption of the names easier than the invention of others. Unsuccessful attempts were made to supplant "puriri," "titoki," "kowhai," with "New Zealand teak," "New Zealand ash," "New Zealand laburnum." Maori and European names have been used indifferently in "rimu," "matai," "kahikatea"—red, black, and white pine; "kotukutuku" and "kohutuhutu" have given way to "fuchsia," or to the now less common misnomer "konini-tree," unless used in the sense that "pear-tree" is used; "makomako" has given place to "wineberry," or "New Zealand currant." In some instances the Maori name has been adopted but corrupted: "matagowry" for "tumatakuru," where "wild-irishman" is not used; "biddy-bid" for "piripiri"; "bunger" (now fortunately seldom heard) for "ponga"; "cracker" (also falling into disuse) for "karaka." "Kowhai" went through many stages—"goa," "gohi," &c., before settling to the two forms "kowhai" in the North and "gowhai" or "gowai" in the South. In one instance the Maori name has been adopted in a translated and shortened form—"parrot's-beak," or "kaka-beak," for "kowhaingutukaka." In some instances the varieties of the trees have been distinguished by the prefixing of a European term to a Maori name—"black mapau," "white mapau"; or the name has, by corruption, been made quite European, and quite wrong, by changing "mapau" to "maple." The various ratas have been more or less distinguished as "shining rata," "southern rata," "white-flowering rata," &c. At first the Maori names were used with hyphens separating the parts—"kowhai-ngutu-kaka"; and, whilst this may be a convenience, enabling easier analysis of a long word, Archdeacon Williams rejects the hyphens and joins the parts — "kowhaingutukaka" — as in the good English "cranesbill." With him the Maori substantive has almost completely shed the hyphen.

Is there any way of arriving at some uniformity of nomenclature, and of avoiding the confusion too often occasioned by the loosely-given common names? "Yes," answers the scientist, one of the most observant of nature's observers, "by the adoption of a fixed nomenclature based on words derived from Latin or Greek; when the name, once adopted, is recognized throughout the scientific world, and may be recognized by the unscientific world also." Devoutly-wished consummation! But the "once adopted" is a stumbling-block and an offence. We were taught by the scientists to speak of the nikau always as *Areca sapida*. That name became quite familiar, when it was discovered that the plant belonged to another genus, and we were bidden to think and write of the nikau no longer as *Areca sapida*, but as *Rhopalostylis sapida*, the genus *Areca* remaining, though the nikau is no longer in its fold, and *Areca sapida* becoming no more than a synonym. Relief from the birch-cum-beech confusion was found in *Fagus*: and later we were required to prefix *Notho-*, referring to our beeches as *Nothofagus* (the southern fagus), and to remember at the same time that *Noto-* when prefixed to other of our plants, as *Notospartium* and *Notothlaspi*, was not a misprint but meant something quite different from *Notho-*—"false," to wit. Even when, in spite of widespread wont, we had accustomed ourselves to thinking and writing of birch as "beech," we were bidden go one further and think and write of it as "southern beech." *Panax* became partly *Nothopanax* and partly *Pseudopanax*. From these changes—and the changing of scientific names is by no means a phenomenon of recent date—has arisen a multiplicity of synonyms (see the pages of Cheeseman, whose lists are not exhaustive) almost equalling in number the synonyms of the bushman; and we begin to suspect the supplanter Jacob the scientist to be no better than his brother Esau the bushman. Potts, knowing a certain fern as *Hymenophyllum montanum*, gave it the common name "the mountain broad-leaved filmy fern." But *H. atrovirens*, the original name, must stand, and the common name remains as witness to the defection of its scientific fellow. His rendering of *Lomaria duplicata* as the double fern was good, but unfortunately did not prevent the original name, *L. capensis*, being adopted. And now, *L. capensis* (= *Blechnum capensis*) being found only at the Cape, the name is to be *Blechnum procerum!*

The changes in the scientific names, however, are not due to any mere casual drift; a goal is in view, and a course has been set out. The *Rules of Botanical Nomenclature*, adopted by the Vienna Congress in 1905, and published in 1906, were sound and good. In every instance the name first given and placed on record is the name to be recognized and finally adopted. A plant may be given a new name provisionally; but if it is found subsequently that it has been placed in the wrong genus the generic name may be changed, but the specific name stands: thus it was that *Areca sapida* became *Rhopalostylis sapida*. By these means a uniformity of nomenclature is certainly a possibility (supposing, of course, that the names are adopted by scientists the world over); and by the complete co-operation of scientists the possibility will speedily become an actuality. The piling of synonyms merely means the shedding of discarded names in favour, not of a new one, but of an earlier and the final one. The synonyms are names that have been given somewhat in the manner that the common names have been given; but whereas it is impossible to say which, if any, of the common names will finally be adopted, in scientific nomenclature there is now a certainty because there is a definite rule, with a definite end in view.

There is much to be said, too, for scientific nomenclature. It offers universal intelligibility. It is, moreover, based on the principle adopted by primeval and uncultured man himself, and by his successors, the settler and bushman. It is in the giving of a name that savage, settler, and scientist alike display imagination or the lack of it. As a general rule, though there are many exceptions, and some dreadful exceptions, the characteristic features of the plant are taken and expressed in the tongue adopted, be it Greek or Latin. *Brachy-glottis*, "broad leaf," is a name that appeals at once to any one familiar with the characteristic foliage of the rangiora. So, too, does *Aci-phylla*, the sharp leaf, to any one familiar with the spaniard: and who is not? *Pteris aquilina*, the "eaglet's wing," is a beautiful name, of instant appeal; and when *esculenta* is added, the appeal is there, though it may be of a lower order. Nor does it matter that *pteris* was the general name in Greek for fern; the poetry of the name-giving is simply more ancient in date—its lineage is proven to be well founded in antiquity. But here we have to remember that in future this form of a name—*Pteris aquilina* var. *esculenta*—is a synonym only; the new name is *Pteridium esculentum*. So *pitto-sporum*, the "pitchy seed"; *hymeno-phyllum*, the "membranous leaf"; *ptero-stylis*, the "winged style" —these are apt names; and, were Greek and Latin vulgar tongues, the names would be adopted at once, and permanently adopted—as *pteris* was adopted. This adoption might be ensured were the signification of the name added in brackets, at least until the name became familiar. This could well be done in popular books and in text-books; the unlettered are not unresponsive to the appeal of beauty, and many of the scientific names are undoubtedly beautiful in meaning. This translation of the scientific name has been done, in a manner, in *The Plants of New Zealand*, by Laing and Blackwell—only there appears to be but little use and not much more help in translating *Chenopodium triandrum* as the "triandrous chenopodium"; *Ixerba brexioides* as the "brexia-like ixerbia"; *Pennantia corymbosa* as the "corymbose pennantia"; and *Calystegia Soldanella* as the "soldanella-like calystegia." The adoption of many scientific names is proof that they are not regarded with rooted aversion, or with an aversion so deeply rooted that it cannot be eradicated.

Geranium, pelargonium, rhododendron, chrysanthemum, gladiolus, calceolaria—all are apt names, pleasing in sound and poetical in concept. But it must be confessed that it was probably neither the aptness nor the poetry that influenced their adoption, for the adopter was usually ignorant of both. Rather their adoption was an indication of the paucity of imagination; adoption, though difficult, was less difficult than invention. How else could antirrhinum be adopted—and eschscholtzia—and even fuchsia?—names of perpetual bane to unfortunate youth. The pronunciation of the last two, furthermore, by no means agrees with the language from which they are derived; and it is an added hardship that as a rule no explanation of the name is offered to the struggling mind; the name is nothing but an unreasonable aggregation of letters. The names are, moreover, inappropriate, being merely names of botanists,—Fuchs (Fox) and Eschscholtz; nor is the latter much easier when we are told that the *t* may now be dropped, "eschscholzia." Without doubt memory is a miraculous gift, and is most patient under abuse. A quotation from Domett may not be out of place:—

> Life's the green Cone-cap hiding for its hour
> That golden Californian poppy-bud;
> Death pulls it off—outbursts the Soul—the flower!
> —*Ranolf and Amohia*, Bk. 1, Can. 5, Sec. 14.

He says of the second line, "The circumlocution . . . necessitated by the infinitely barbarous scientific name given to the beautiful flower 'Eschscholtzia'!" Of names of this kind there are many adopted—"lobelia," "camellia," "godetia," "boronia"—names immortalized, and in how fugitive creations! "Kniphofia" has not been adopted, and there is little wonder in that. Gardeners use the alternative name "tritoma"; but the popular names are "torch-lily," "red-hot poker"; and to which namer must be awarded the palm for imagination?

Scientists often have themselves to blame if their names are rejected: what cause other than perversity originated such names as *Tmesipteris*, *Ehrharta*, *Staehelina*, *Mniarum*, *Rhabdothamnus?* They do but court rejection, and deserve it. An excellent usage, too, has been too seldom followed: why not use the Maori name as the specific name? This was done in *Podocarpus totara*, in *Beilschmiedia taraire*, in *Beilschmiedia tawa*. It is too late to remedy the omission now, or we might have *Alectryon titoki*, *Aristotelia makomako*, *Edwardsia kowhai*, and the like graceful wedding of the old and the new.

Setting aside, too, the difficulties presented by a strange tongue to innocence when it meets an unusual word like *pteris*, the scientist in his speech often still further disguises and makes repellant the name which otherwise might appeal. As often as not, he pronounces "pit'to-sporum" "pittos'porum"; "a'ci-phylla" "aciph'ylla"; and so on. Mr. G. M. Thomson gives a little sage advice on this point: "I take it," he says, "that without being pedantic the pronunciation should as far as possible follow the derivation." The inconsistency of accentuation, too, is a puzzle: if "pittos'porum," and not "pit'to-sporum," why not "dracoph'yllum" and "pteros'tylis," and not "drac'o-phyllum" and "pter'o-stylis"? And, whilst he has not heard it, the writer learns that "pteros'tylis" is not unknown. Field has a paragraph to the point: "As my book is intended chiefly for unlearned readers, to the names of the ferns at the heads of the descriptions and elsewhere I have appended a guide to the pronunciation, to prevent such common mistakes as pronouncing Hymenophyllum (Hymen-o-phyl-lum), which means 'filmy leaf'; Hymenophilum (Hymen-oph-il-um), which would mean 'film-loving,' and be nonsense: or calling Gleichenia, in which the *ei* has the hard sound of *i* in 'file,' the *ch* is a guttural, and the second *e* scarcely sounded, as if it were written Glikeenia or Gleekeenia." In the pronunciation of "Hymenophyllum" he follows Johnson, who in *The Gardener's Dictionary* gives it as "hymenophy'llum," and Wright, who in his *Encyclopaedia of Gardening* gives it as "Hymen-ophyl-lum." The name "Alsophila" Field prints "Al-soph-il-a," and here the accent is correctly placed on the "*o*," following Johnson and Wright, who print a word of similar derivation, gypsophila, "gypso'phila" and gypso'ph-ila respectively. The reason for the difference is in the difference of the root:—

Hymen, a membrane;	*phyllon*, a leaf.
Alsos, a forest;	*phileo*, to love.
Gypsos, chalk;	*phileo*, to love.

The confusion in accentuation is no doubt partly due to the close resemblance of the words; but the confusion might be avoided were the roots and meaning given with the name in the first place—unless, that is, botany is to be only a written science.

It is true, too, that this curious shifting of the accent appears to follow an inexplicable tendency in our language; for whilst we say tel'egraph, arith'metic, ad'vertise, we say teleg'raphy, arithmet'ical, adver'tisement:

the derivation is revealed in one word, concealed in its fellow. In following this apparently instinctive law, we say, not *te'tra-ptera*, but *tetrap'tera*, giving a fuller sound to the *p* than it had, or than we suppose it had, in the original. In *ptera* the *p* was so subdued that the *pt* is ordinarily represented by *t;* and it is no doubt due to the desire for easier pronunciation of what looks like the representation of a double sound that the *p* and *t* have been separated, making two sounds of what should be one. *Tetrap'tera* has its parallel in another science— entomology —where *tetrap'terous* is used instead of *tetra-pterous* (four-winged). Here, too, a whole series of generic names is given an English accent—*lepidop'tera*, *hymenop'tera*, *neurop'tera*, *dip'tera*, &c., instead of *le'pido-ptera* (scaly-winged), *hy'meno-ptera* (membranous-winged), *neu'ro-ptera* (nervenet-winged), *di'-ptera* (two-winged), &c.; yet in the parallel words *lep'idosau'ria*, *lep'idosi'ren*, and *lep'idoden'dron* the root accent is given.

If this shifting of the accent be in obedience to a linguistic law, we must, will we, nill we, abide by it, contenting ourselves merely with pointing out that the law is inconsistent, and that certain persons do aid and abet it in its inconsistency. But then, our vigorous and felicitous tongue is such an agglomeration of inconsistencies, to our seeming, that a few more or less hardly matter—except to the unfortunate struggling for expression. Parallel formations exert an influence, and the familiar pronunciation of the combination *apt* would no doubt present itself unconsciously to the thought when a new combination, such as *apteryx* was met, and hence the common *ap'-teryx*, instead of *a-pte'ryx* (without wings). In *pte'ro-dactyl* the sound of the *p* has been dropped since the *pt* begins the word: why not when it begins the syllable within the word?

In volume 51 of the *Transactions of the New Zealand Institute*, pp. 409–14, Professor A. Wall expresses himself in a paper, wide in interest, if pessimistic in tone, regarding the pronunciation of scientific terms. He suggests the adoption of certain classical pronunciations, to be decided upon by a proposed committee, and adopted by future scientists. But even if, in the first place, the scientists themselves were able to agree on the pronunciations to be adopted, and would use them consistently when adopted, they form but a small section of the public, and any attempt of theirs to stem the set of popular pronunciation would be, as Professor Wall fears, foredoomed to failure. If certain linguistic laws govern the sound of phonetics when adopted by one language from another, Latin and Greek phonetics cannot escape that law, nor can the change be prevented, however much it may offend the ear: it were perhaps easier to remove the offence by modifying the individual ear. Then, too, pronunciation is not fixed; and the committee, if appointed, were like to prove a perennial—and a struggling perennial. Moreover, botanical treatises are far more often written than spoken, and in writing or reading pronunciation is of no moment; and, as one leading scientist has said, "whichever way the word is pronounced, I know what is meant, and that is the main thing."

It has been noted that in giving the generic name some characteristic of the plant has been seized on, and from this many good names result. There is more difficulty in giving the specific name, though here advantage may be taken of minor distinguishing characteristics. This is well seen in the specific names of the genus *Veronica*—*buxifolia*, *diosmaefolia*, *dasyphylla*, *leiophylla*, *ligustrifolia*, *pinguifolia*, *salicifolia*, where the leaf-difference has been taken as the characteristic; *acutiflora*, *parviflora*, *uniflora*, where the flower has been taken; *cupressoides*, *loganioides*, *lycopodioides*, *pimeleoides*, where its resemblance to some other plant has been taken; and so on. But there is nothing descriptive in such specific names as *Balfouriana*,

Barkeri, Benthami, Bidwillii, Buchanani, Buxbaumii—to take the *Bs* only in this variable genus. Sometimes this proper name is the name of the discoverer of the species, and it is then tolerable; sometimes it is the name of a good worker in this or another science, when it is barely tolerable; sometimes it is the name of a friend of the name-giver, when it becomes unreasonable. The aggravation is as acute when the common name is made merely a translation of a name of this kind—Buchanan's veronica; and it is a pleasure to find that in Dr. Cockayne's book, already referred to, this system of common naming has been discarded. There is surely no plant so undistinguished that it has no characteristic of which advantage may be taken in giving a name; it certainly can have no common name unless it have some characteristic, in appearance, or use, or obtrusiveness, upon which the common mind is able to fasten, even if it receive a name like the "innominate" of osteology.

Dr. Cockayne has made a considerable beginning in the invention of common names for the lesser known New Zealand plants; and, whilst he shows inconsistency, it is palpably no more than the inconsistency of a mind working towards a definite end in the midst of much difficulty and obscurity. He adopts one name, and later on discards it for one he considers more appropriate. Many of the names given bear their own warrant of adoption, many as sure a warrant of their rejection. In the naming of ferns he has in most instances followed Potts, one of our early and most prolific name-givers; and in the naming of grasses he has followed Buchanan—hyphen in hand. Objection has already been taken to the naming of *Carpodetus serratus* "New Zealand hawthorn"; and objection must also be made to such names as "common mountain shrubby groundsel," "persicaria-leaved pond-weed," "broad-leaved tussock oat-grass." This is not name-giving, it is description. And the objection of length may almost as reasonably be urged against these names as against such scientific names as *Anthurium Scherzerianum album maximum flavescens*, the name given to the white-flowered anthurium (*Gardener's Chronicle*, 1886, p. 187). "Gentian" is a good name; "New Zealand gentian" is hardly a new name, still less is "common New Zealand gentian"—they simply modify an old name. So the various willowherbs are distinguished by a characterizing adjective; but these are not names. It is not necessary that all willowherbs should have that name with modifying adjective. True, the "bottle-campion" is a variety of the campion, as are the "red campion" and the "white campion"; but so are the "ragged robin," the spotted catch-fly, and the "German catch-fly." The mind to which a common name appeals is not concerned whether or no that name reveals the relation of the plants one to another; if the name and the plant are well mated, that is sufficient. "Hart's-tongue" and "maiden-hair" are sufficient without the addition of "fern"; the names catch the imagination. "Oak" and "poplar" need no addition to tell the common mind they are trees. In Dr. Cockayne's book, "three-square" as a name for *Scirpus americanus* is a true name, and seems good; good names, also, are "star-lily," "coral-shrub," "bell-vine," "pen-wiper plant"; and there is little doubt that once our New Zealand plants become thoroughly well known, through such excellent books and papers as Dr. Cockayne's, many of his tentative names will irrevocably be discarded for others, more concise if perhaps less descriptive. And one of the first to accept the new names will be Dr. Cockayne. It is no easy matter to invent a new name; and it is not, perhaps, the scientist to whom we should look for the new names, but his complement, the poet; and he does no more than give expression to feelings that had first to be general before he might win the power of

enduring expression. It is this general feeling that gives the charm to Bridges's poem "The Idle Flowers":—

I have sown upon the fields
Eyebright and Pimpernel,
And Pansy and Poppy-seed
Ripen'd and scatter'd well,

And silver Lady-smock,
The meads with light to fill,
Cowslip and Buttercup,
Daisy and Daffodil;

King-cup and Fleur-de-lys
Upon the marsh to meet
With Comfrey, Watermint,
Loose-strife and Meadowsweet;

And all along the stream
My care hath not forgot
Crowfoot's white galaxy
And love's Forget-me-not:

And where high grasses wave
Shall great Moon-daisies blink,
With Rattle and Sorrel sharp
And Robin's ragged pink.

Thick on the woodland floor
Gay company shall be,
Primrose and Hyacinth
And frail Anemone,

Perennial Strawberry-bloom,
Woodsorrel's pencilled veil,
Dishevel'd Willow-weed
And Orchis purple and pale,

Bugle, that blushes blue,
And Woodruff's snowy gem,
Proud Fox-glove's finger-bells,
And Spurge with milky stem.

And so for thirteen stanzas more. These are real and enduring names, and many of the wildings gracing them have been acclimatized here. When will the names of our New Zealand wildings be acclimatized in British poetry?

The following lists cannot and do not claim to be complete: the net has been cast widely, but it is certain that many names have not been caught. The lists, will, however, serve as a basis, to which other names may be added from time to time as discovered or created. In many instances the authorities quoted do not adopt the name or use it themselves, but simply quote it as being in common use. The list of scientific names is published with this paper; the list of popular names and the list of authorities will be published in the next volume.

It is unsafe to make any rule; it is almost unsafe to make any suggestion: language has an individuality of its own, a complex individuality that will not brook interference; its users, too, have an individuality that will brook less: but might it be suggested that the common name marked with a star appears to commend itself for general adoption. There is, of course, always room for a good name, always room for a better; and these need not be regarded as fixed stars. When the starred name is enclosed in brackets it is a name that the author has not met in print, but is suggested as appropriate. It seems hardly necessary to suggest any name at all when the plant is so undistinguished as usually to pass unobserved; a scientist needs only the scientific name; to the layman a suggested name would mean no more than the scientific name: when the plant becomes noticeable, through closer association, its name will come with it. It is probable that popular names come largely through children and unlettered people, and are introduced into literature by poets.

A few naturalized plants have been included, some because they have received Maori names, some because they have joined a family well represented in New Zealand. In these cases a dagger † precedes the scientific name. Garden varieties such as *Brachyglottis rangiora purpurea* (bronze-leaved rangiora), *Phormium tenax Williamsii variegata* (broad-leaved flax with yellow variegations), have not been included; they might be included could they be identified with Maori varieties, and should be included did they become recognized fixed varieties. A few plants now recognized as hybrids have been marked ×.

SCIENTIFIC, MAORI, AND COMMON NAMES OF NEW ZEALAND PLANTS.

Names suggested for adoption starred *; if in brackets, the name has not appeared in literature, at least in the form suggested. Naturalized plants are marked †; hybrids, ×.

Acaena adscendens :[1]
silver piripiri

Acaena inermis :
spineless piripiri

Acaena microphylla :
small-leaved acæna

Acaena novae-zelandiae :
New Zealand acæna
New Zealand burr
red biddy-bid
red New Zealand burr
red piripiri
*(red burr)

†*Acaena ovina* :
Australian piripiri

Acaena Sanguisorbae :
huruhuru-o-Hinenuitepo
hutiwai
kaia
kaiarureruro
kaikaia
kaikaiaruhe
kaikaiaruro
pirikahu
*piripiri
piriwhetau

beta-beta
bid-a-bid
biddy-bid
biddy-biddy
*biddybiddy
bidi-bidi
common burr
green biddy-bid
native burr
New Zealand burr

Acaena Sanguisorbae var. *minor* :
antarctic burr
antarctic piripiri
*(polar burr)

Acaena Sanguisorbae var. *pilosa* :
mountain piripiri

Aciphylla Ashcroftii :[2]
speargrass

Aciphylla Colensoi :
kurikuri
taramea

bayonet grass
bayonet-grass
bayonet plant
bayonette grass
bloody Spaniard
bloody-Spaniard
Colenso's Spaniard
Spaniard
*spear-grass

Aciphylla Colensoi var. *maxima* :[3]
greater-spaniard

Aciphylla Lyallii :
bayonet plant

Aciphylla Lyallii var. *crenulata* :
saw-leaved Spaniard

Aciphylla maxima ;
giant spaniard

Aciphylla Monroi :
alpine spear grass
little spaniard
Monro's Spaniard
tiny spear-grass
*(pigmy spear-grass)

Aciphylla squarrosa :
karamea
kurikuri
papaii (= the young form)
*taramea
tumatakuru

bayonet plant
rough Spaniard
*spaniard
spear grass
spear-grass
speargrass
spur-grass
wild Spaniard

Aciphylla Traillii :
Stewart Island spaniard
Stewart Island spear-grass

Ackama rosaefolia :
makaka
*makamaka[4]

Adiantum :
*maidenhair

Adiantum aethiopicum :
African maidenhair
creeping maiden hair
English maidenhair
maidenhair
*rock-fern
small-leaved maidenhair

Adiantum affine :
common maidenhair
Cunningham's maiden hair fern
large-leaved maidenhair
maiden hair

Adiantum diaphanum :
little maidenhair
thin-leaved maidenhair

Adiantum formosum :
giant maiden-hair
giant maidenhair
*plumed maidenhair
plumed maiden hair fern

Adiantum fulvum :
brown-stemmed maiden-hair

Adiantum hispidulum :
hairy maidenhair
hairy maiden hair fern

Aecidium kowhai :
—— *myopori* :
*witches-broom

Agaricus adiposus :
haroro (also a general term for fungi)

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[1] Found only on Macquarie Island, the mainland plant being *A. sanguisorbae*.
[2] No such name now recognized.
[3] Name not now recognised; the same as *A. maxima*.
[4] The name *Ackama* is intended as an anagram of makamaka.

Agathis australis :
kapia (= the resin)
*kauri

caudie
coudy
cowdy
cowrie-pine
cowry
kaudi
kaudi-tree
kauri pine
king-pine
koudi pine
kowdie-pine
New Zealand fir
New Zealand yellow pine
olive-leaved cedar
yellow pine

Ageratum conyzioides :
cherry pie
cherry-pie
*wild heliotrope

Agropyron multiflorum :
short-awned wheat grass

Agropyron scabrum :
patiti
patiti-taranui

blue-grass
blue wheat grass

Agropyron squarrosum :[1]
blue grass

Agropyron Youngii :
blue grass *var.*

Agrostis Dyeri :
brown bent
brown bent grass
New Zealand bent-grass
*(Maori bent)

Agrostis Forsteri (Deyeuxia filiformis and *D. Forsteri) :*
*perehia
repehina
toheraoa
turikoka

toothed bent grass
toothed bent-grass
*(toothed bent)

Agrostis parviflora :
slender bent grass
small-flowered bent-grass

Agrostis pilosa (Deyeuxia filiformis var. *pilosa) :*
pilose bent grass

Agrostis subulata :
alpine bent grass
alpine bent-grass
dwarf mountain bent grass

Alectryon excelsum :
tapitapi
*titoki
titongi
tokitoki
tongitongi
topitopi

lofty alectryon
native ash
New Zealand ash
New Zealand oak
pitoko

Aleurites moluccana :
candle-nut
*candlenut

Alopecurus geniculatus :
knee-jointed fox-tail grass
marsh foxtail

Alseuosmia Banksii :
matukuroimata
*pere

Alseuosmia linearifolia
matukuroimata

Alseuosmia macrophylla :
horopito
*karapapa
kokotaika
toropapa

honeysuckle
large-leaved alseuosmia
shrubby honeysuckle

Alseuosmia quercifolia :
matukuroimata
*toropapa

oak-leaved alseuosmia

Alsophila Colensoi :
creeping tree fern
golden tree-fern
grove fern
mountain tree-fern
*(grove-fern)

Alternanthera sessilis :
mahuri
nahui

Angelica geniculata :
climbing-aniseed
jointed angelica
*(climbing-anise)

Angelica Gingidium :[2]
naupiro

native anise

Angelica montana :
anis
anise
aniseed
native aniseed
New Zealand aniseed
*(Maori anise)

Angelica rosaefolia :
kohepiro
*koheriki
kumarahou

aniseed
*rose-leaved anise

Angelica trifoliolata :
*bog-anise

Anisotome :
pinakitere

native parsley
*(Maori parsley)

Anisotome aromatica :
*kopoti

common alpine ligusticum
common anisotome

Anisotome carnosulum :
fleshy ligusticum

Anisotome Enysii :
rock-anisotome

Anisotome latifolium :
broad-leaved ligusticum

Anisotome Lyallii :
*Maori parsnip

Anisotome piliferum :
bristly ligusticum

Apium australe :[3]
tutaekoau

[1] No such name now recognized; perhaps syn. for *A. scabrum*.
[2] Name not now recognized; the same as *A. montana*.
[3] Name not now recognized; the same as *A. prostratum*.

Apium filiforme :
slender celery
slender New Zealand celery
wild celery

Apium prostratum :
Australian celery
celery
native celery
New Zealand celery
prostrate parsley
*(Maori celery)

×*Aristotelia Colensoi* :
Colenso's wineberry

Aristotelia fruticosa :
*mountain-currant
mountain wineberry
shrubby aristotelia

Aristotelia serrata (racemosa) :
*makomako

light-wood
lime tree
moko-mok
moko-moko
native currant
New Zealand currant
New Zealand wineberry
racemose aristotelia
wine berry
wine-berry
*wineberry

Arthropodium candidum :
repehina-papa

*star-lily
white arthropodium

Arthropodium cirratum :
maikaika
popohui
rengarenga

curled arthropodium
Mabel Island lily
New Zealand lily
North Island lily
renga lily
rock lily
rock-lily
*(renga-lily)

Arthropteris tenella :
tender polypody

Arundo conspicua :
*toetoe
toetoe-kakaho
kakaho (= the culms)
kokaho (prob. kakaho)

Arundo conspicua—cont.
cutting grass
erect - plumed tussock-grass
flag
New Zealand reed
pampas grass
plumed tussac grass
plume grass
*plume-grass
sword-grass
toe-toe grass
toetoe grass
toetoe-grass
tohe-tohe
tohi grass
toi-grass
toi-toi grass

Arundo fulvida :
erect plumed tussac grass

Ascarina lucida :
*hutu

glossy ascarine

Asperella gracilis :
slender glumeless grass

Asperula perpusilla :
dwarf bedstraw
*woodroof

Asplenium adiantoides :
peretao
*petako
waro

drooping spleenwort
*lance-leaved spleenwort
shining-spleenwort

Asplenium bulbiferum :
maku
manamana
mauku
moku
*mouki
mouku

carrot-top
common spleenwort
mother-fern
prolíferous spleenwort
*(cradling fern)

Asplenium caudatum :
tailed spleenwort

Asplenium Colensoi :
Colenso's spleenwort

Asplenium falcatum :
peretao
*petako

Asplenium flabellifolium :
drooping spleenwort
drooping-spleenwort
necklace fern
*necklace-fern
rat-tail spleenwort
whip-cord

Asplenium flaccidum :
maireire
*makawe
pohutukawa
raukatauri
whiri-o-Raukatauri

drooping spleenwort
drooping-spleenwort
hanging-tree spleenwort
pendant spleenwort
*pendent spleenwort

Asplenium Hookerianum :
Hooker's spleenwort
*maidenhair spleenwort

Asplenium lucidum :
*huruhuruwhenua
panako
paranako
parenako
paretao

*shining spleenwort
shining-spleenwort

Asplenium Lyallii :
Lyall's spleenwort

Asplenium obtusatum :
panako
*paranako
parenako
paretao

blunt leafed spleenwort
lime-spleenwort
sea spleenwort
sea-spleenwort
shore spleenwort
*shore-spleenwort

Asplenium Richardi :
carrot fern
Richard's spleenwort
Richards' spleenwort
*(carrot-fern)

Asplenium scleroprium :
toothed shore spleenwort

Asplenium Trichomanes :
maidenhair spleenwort
rock spleenwort
wall spleenwort

Astelia :
mauri

cotton plant
perching-lilies

Astelia Banksii :
horahora
kowharawhara
puwharawhara
*wharawhara

shore-kowharawhara

Astelia Cockaynei (montana) :
alpine astelia
alpine bush-flax
*mountain-astelia

Astelia Cunninghamii :
kahakaha
*kokaha
kowharawhara
takahakaha (= when in flower)

perching-kowharawhara

Astelia linearis :
dwarf astelia

Astelia montana. See *A. Cockaynei*.

Astelia nervosa :
kakaha

bush flax
bush-flax
*bush-lily
common astelia
giant astelia
swamp-astelia
swamp-asteliad

Astelia Solandri :
*kahakaha

perching kahakaha
perching lily
*tree-flax

Astelia subulata :
sharp-leaved creeping astelia

Astelia trinervia :
kauri grass
*kauri-grass

Atriplex crystallina (Billardieri) :
New Zealand orache

†*Atriplex patula* :
spreading-orache

Atropis novae-zealandiae :
New Zealand atropis

Atropis stricta :
*salt grass
sweet grass

Avicennia officinalis :
*manawa
paetai
tuputupu
waikure

*mangrove
white mangrove

Azolla rubra :
karerarera
*retoreto

floating water-fern
*red azolla

Barbarea vulgaris :
toi

Beilschmiedia taraire :
*taraire

laurel-tree

Beilschmiedia tawa :
mariri (= the unripe fruit)
pokere (= the fruit)
pokerehu (= the fruit)
*tawa

New Zealand's damson

Bidens pilosa :
*kamu
koheriki

*cowage

Blechnum (Lomaria) :
*hard fern
hard-fern

Blechnum alpinum :[1]
narrow hard-fern

Blechnum Banksii :
Bank's hard fern
Banks' hard fern
shore hard-fern

Blechnum capense.[2] See *B. procerum*.

Blechnum discolor :
*petipeti
piupiu
taniwhaniwha

common hard fern
*crown-fern
fishbone-fern
New Zealand's bird's nest fern

Blechnum durum :
coastal hard-fern
thick-leaved hard fern
thick-leaved hard-fern

Blechnum filiforme :
panako

climbing hard fern
climbing hard-fern
*thread-fern

Blechnum fluviatile :
kawakawa
*kiwikiwi

creek fern
*creek-fern

Blechnum Fraseri :
Frazer's fern
mimic tree-fern
miniature tree-fern

Blechnum lanceolatum :
nini
*rereti

lance-leaved fern
lance-leaved hard fern
Tasmanian hard fern

Blechnum membranaceum :
membrane-leaved fern

Blechnum nigrum :
black hard fern
black hard-fern

Blechnum Norfolkiana :
thin-leaved hard fern

Blechnum paleacea :[3]
bronze-leaved fern

Blechnum Patersoni :
peretao

broad-leaved hard-fern
Paterson's fern

Blechnum penna marinum :[4]
alpine hard fern
alpine hard-fern
little hard fern

[1] Now included in *B. penna marina*.
[2] Name to be changed to *B. procerum*, which see.
[3] No such name now recognised.
[4] This is now the accepted name also of *B. alpinum*.

Blechnum procerum (Forst. f.) J. C. Andersen = *B. capense* Schlecht. in Cheeseman, *Man. N.Z. Flora*, ed. 2, pp. 58–59:
horokio
*kiokio
korokio
koropiu
piupiu
tupari

double fern
long hard fern
long hard-fern
palm-leaved fern

Blechnum vulcanicum:
korokio

triangular hard fern
triangular hard-fern

Bolbophyllum pygmaeum:
pygmy bolbophyllum

Botrychium:
*moonwort

Botrychium australe:
moonwort

Botrychium flabellifolium:[1]
parsley fern

Botrychium lunaria
*moonwort

Botrychium ternatum:
patotara
moonwort

parsley fern
parsley-fern
rattle-snake fern
*rattlesnake fern

Brachycome odorata:
*roniu

Brachycome Sinclairii:
daisy
*grassland-daisy
native daisy
Sinclair's brachycome

Brachyglottis rangiora:
*rangiora

Brachyglottis repanda:
pukapuka
pukariao
rangiora
raurakau
*wharangi
wharangitawhito

Brachyglottis repanda—ctd.
paper leaf
wavy-leaved rangiora
*(paper-leaf)

†*Brassica campestris*:
keha
korau
nani
pohata

†*Brassica oleracea*:
paea

Captain Cook cabbage
Maori cabbage

Bromus arenarius:
sea-side brome grass
*seaside brome-grass

Bulbinella Rossii:[2]
Ross's bulbinella

Bulbophyllum pygmaeum:
piripiri

Caladenia Lyallii:
Lyall's caladenia

Caladenia minor:
lesser caladenia

Calamagrostis. See *Deyeuxia*.

Calceolaria. See *Jovellana*.

Callitriche:
*water-starwort

Callitriche Muelleri:
southern water star-wort

Caltha novae-zelandiae:
marsh marygold
New Zealand caltha
New Zealand marsh-marigold
*(Maori marigold)

Calystegia sepium:
akapohue
nahinahi
panahe
panahi
*panake
pohue
rauparaha

bell climber
*bell-vine
bind-weed
bindweed
convolvulus

Calystegia Soldanella:
bindweed
sand bindweed
sand-convolvulus
shore convolvulus
shore-convolvulus
soldanella-like calystegia
*(sandbine)

Calystegia tuguriorum:
powhiwhi

climbing convolvulus
climbing-convolvulus
native convolvulus
New Zealand convolvulus
smaller bindweed
*(Maori convolvulus)

Cardamine in part. See *Radicula Nasturtium*.

**Cardamine depressa*:
ladies' smock

Cardamine heterophylla:
hanea
*panapana

bitter-cress
hairy bitter-cress
hairy cardamine
New Zealand cress
*(Maori cress)

Cardamine heterophylla var. *uniflora*:
few-leaved bitter-cress

†*Cardamine hirsuta*:
land-cress

Carex appressa:
tall sedge
tupak grass

Carex comans:
*maurea
hair-like sedge

Carex Darwini var. *urolepsis*:
sedge

Carex dissita:
flat-leaved sedge.

Carex dissita var. *monticola*:
mountain-sedge

Carex litorosa:
salt-marsh sedge
*sea-sedge

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[1] No such name now recognised.
[2] Now included in *Chrysobactron Rossii*.

Carex longiculmis
long-stalked sedge

Carex lucida :
*mania
maurea
*shining sedge

Carex Oederi var. *catarractae :*
*yellow sedge

Carex pseudo-cyperus var. *fascicularis :*
cyperus-sedge

Carex pumila :
creeping-sedge
dune sedge
*dune-sedge
sand-sedge

Carex pyrenaica :
Pyrenees sedge

Carex secta :
*purei
nigger head
nigger-head
*niggerhead

Carex Solandri :
Solander's sedge

Carex stellulata var. *australis :*
*prickly sedge

Carex teretiuscula :
*makura
mata
purekireki

Carex ternaria :
*rautahi
toetoe-rautahi
cutting-grass

Carex testacea :
*slender sedge

Carex trifida :
*great sedge
sedge

Carex uncifolia :
hook-leaved sedge
*(hook-sedge)

Carex virgata :
Maori head
nigger-head
smaller swamp-sedge
small swamp-sedge

Carmichaelia australis :
*makaka
tainoka
taunoka
austral broom
austral-broom
New Zealand broom
red-seeded broom
southern carmichaelia
tall native broom
*(Maori broom)

Carmichaelia Enysii :
Enys's native broom

Carmichaelia flagelliformis :
*maukoro
native broom
New Zealand broom
slender broom
slender native broom
slender New Zealand broom
whip-like carmichaelia
*(whip-broom)

Carmichaelia gracilis :
climbing-broom
climbing New Zealand broom

Carmichaelia grandiflora :
large-flowered broom
large-flowered New Zealand broom

Carmichaelia grandiflora var. *alba :*
*alpine broom

Carmichaelia Monroi :
stout dwarf broom

Carmichaelia nana :
common dwarf broom
dwarf carmichaelia

Carmichaelia odorata :
pink broom
scented broom
*sweet-broom
tall New Zealand broom

Carmichaelia paludosa :
*swamp-broom

Carmichaelia subulata :
common New Zealand broom
leafless common New Zealand broom
native broom

Carpha alpina :
alpine carpha
common carpha

Carpodetus serratus :
kaiweta
piripiriwhata
*punaweta
putaputaweta
New Zealand hawthorn
oak
serrate carpodetus
snow-tree
weta
white birch
white mapau
white maple
white matipo
*(Maori may)

Cassinia fulvida :
*golden cottonwood
yellow cassinia
yellow shrub

Cassinia leptophylla :
tauhinu-korokio
tauhinu-koromiko
cottonwood
narrow-leaved cassinia
*(fragrant cottonwood)

Cassinia Vauvilliersii :
mountain cassinia
*mountain-cottonwood
Vauvillier's cassinia
yellow-leaved mountain cottonwood

Cassytha paniculata :
mawhai
konene (= the fruit)

Celmisia :
horse daisy
mountain aster
New Zealand daisy
*(Maori daisy)

Celmisia argentea :
silver cushion-celmisia
silvery celmisia
silvery cushion-celmisia
silvery mountain-daisy

Celmisia bellidioides :
green cushion-celmisia

Celmisia coriacea :
tikumu
cotton plant
leather plant
leathery celmisia
mountain daisy
silvery cotton-plant
white mountain daisy

Celmisia discolor :
*mountain-musk

Celmisia glandulosa var. *latifolia* :
bog celmisia
*bog-celmisia

Celmisia gracilenta (longifolia) :
*pekepeke

common celmisia
cotton grass
cotton-grass
long-leaved celmisia

Celmisia holosericea :
pekepeke

aster

Celmisia incana :
mountain musk
mountain-musk
*white mountain-musk

Celmisia intermedia :
*hoary mountain-musk

Celmisia laricifolia :
cotton plant
*needle-leaved celmisia

Celmisia linearis :
*narrow-leaved celmisia

Celmisia longifolia. See *C. gracilenta.*

Celmisia Lyallii :
blunt-leaved spaniard
blunt spaniard

Celmisia Monroi :
rock cotton-plant

Celmisia rigida :
Stewart Island celmisia

Celmisia sessiliflora :
short-flowered celmisia
white cushion-celmisia

Celmisia Sinclairii :
mountain-musk
Sinclair's celmisia

Celmisia spectabilis :
*puakaito
puhaeretaiko
puwharetaiko
tikumu

common cotton-plant
cotton plant
cotton-plant
leather-plant

Celmisia Traversii :
brown mountain daisy
Travers' celmisia

Celmisia vernicosa :
varnished celmisia

Celmisia viscosa :
*snow-celmisia

Centella uniflora (Hydrocotyle asiatica) :
Asiatic hydrocotyle
Asiatic marsh pennywort
Asiatic marsh-pennywort

Chaetomorpha Darwinii :
mermaids' beads
*(mermaids-beads)

Cheilanthes Sieberi :
Sieber's fern
rock-fern

Cheilanthes tenuifolia :
thin-leaved cheilanthes

†*Chenopodium album* :
huainanga

Chenopodium detestans :
fish-guts plant

Chenopodium glaucum var. *ambiguum* :
oak-leaved goose-foot

Chenopodium pusillum :
parahia

Chenopodium triandrum :
*poipapa

spinach
triandrous chenopodium

Chrysobactron Hookeri :
Maori onion
*swamp-lily

Chrysobactron Hookeri var. *angustifolium* :
*bog-lily

Chrysobactron Rossii :[1]
Maori onion
orange-coloured swamp-lily

Cladium articulatum :
jointed twig-rush

Cladium Gunnii :
Gunn's twig-rush

Cladium junceum :
swamp twig-rush

Cladium Sinclairii :
pepepe
toetoe-tuhara
*tuhara

Cladium teretifolium :
common twig-rush

Cladium Vauthiera :
square-stemmed twig-rush

Clathrus cibarius (Ileodictyon cibarium) :
kokirikiri-whetu
kopura-whetu
kopuru-whetu
korokoro-whetu
paru-whatitiri
pukurau
tutae-kehua
tutae-whatitiri
*tutae-whetu
wheterau

basket fungus
devil's purse
fairy's closet
lattice fungus
net fungus
shepherd's basket fungus
*(basket-fungus)

Clematis :
virgin's bower

Clematis afoliata :
leafless clematis
yellow-flowered leafless clematis

Clematis Colensoi :
yellow clematis

Clematis hexasepala :
pikiarero
poananga
potaetae
puatataua
*puataua
puatautaua

six-sepaled clematis
smaller white clematis
small white clematis
traveller's joy

Clematis indivisa :
pikiarero
puapua
*puawananga
puawhananga

[1] Includes *Bulbinella Rossii*, which see.

Clematis indivisa—cont.
clematis
entire-leaved clematis
native clematis
New Zealand clematis
traveller's joy
white clematis

Clematis parviflora :
akangakaukiore
ngakaukiore
pokopokonuiahura

Clianthus puniceus :
kowhai-ngutukaka

glory pea
kaka beak
kaka-bill
parrotbill
parrot's beak fuchsia
parrot's bill
parrot's-bill
red kowhai
red parrot's bill
scarlet clianthus
*(parrotsbill)

Colensoa physaloides :
*koru
oru

physalis-like colensoa
thin-leaved oru

Colocasia antiquorum :
*taro
Cultivated varieties—
akarewa
awanga
haukopa
kahuorangi
kakatarahae
kinakina
koareare
kohuorangi
kohurangi
makatiti
mamaku
matatiti
ngaue
ngongoro
paeangaanga
pakaue
patai
pehu
pongi
potango
takatakapo
tanae
taro-hoia (recently introduced)
tautamahei
tokotokohau
turitaka
upokotiketike
wairuaarangi

Convolvulus erubescens :
blushing convolvulus
common convolvulus
*(blush-convolvulus)

Coprosma :
coffee-bush
New Zealand coffee
*(Maori coffee)

Coprosma acerosa :
tarakupenga
tatarahake
tataraheke

acerose coprosma
dune coprosma
dune-coprosma
*sand-coprosma

Coprosma arborea :
mamangi

tree coprosma
tree-coprosma
tree karamu

Coprosma areolata :
areolate coprosma
thin-leaved coprosma

Coprosma Banksii :
Banks's coprosma

Coprosma Baueri See *C. retusa.*

Coprosma chathamica :
tree-karamu

Coprosma ciliata :
hairy coprosma

Coprosma Colensoi :
Colenso's coprosma

Coprosma crassifolia :
stiff-stemmed coprosma

Coprosma cuneata :
wedge-leaved coprosma

Coprosma depressa :
prostrate coprosma

Coprosma foetidissima :
hupirau-ririki
*hupiro
karamu
naupiro
pipiro

evil-smelling hupiro
evil-smelling karamu
foetid coprosma
luma-luma
sterile wood
stinkwood

Coprosma grandifolia :
*kanono
kapukiore
karamukueo
kawariki
kueo (= berries)
manono
papauma
patutiketike
raurakau
raurekau
tapatapauma

large-leaved coprosma
yellow wood

Coprosma linariifolia :
mikimik
narrow-leaved coprosma
yellow karamu
yellow wood
yellow-wood

Coprosma lucida :
kakaramu
karamu
karangu
patutiketike

broad-leaf
coffee tree
orange-leaf
shining coprosma
yellow-wood

Coprosma microcarpa :
small-fruited coprosma

Coprosma parviflora :
leafy coprosma
small-flowered coprosma
small-leaved coprosma

Coprosma Petriei :
Petrie's coprosma
turfy coprosma

Coprosma propinqua :
mingi

common coprosma
kindred coprosma

Coprosma ramulosa :
straggling coprosma

Coprosma repens :
alpine creeping coprosma

Coprosma retusa (Baueri) :
angiangi
mamangi
naupata
*taupata

coastal coprosma
retuse coprosma

Coprosma rhamnoides :
red-fruited coprosma

Coprosma robusta :
kakaramu
kakarangu
*karamu
karamuramu
karangu

common karamu
glossy coprosma
glossy karamu
red-berry
robust coprosma

Coprosma rotundifolia :
round-leaved coprosma

Coprosma rugosa :
heath-like coprosma

Coprosma tenuicaulis :
*hukihuki

slender coprosma
swamp-coprosma

Coprosma tenuifolia :
soft-leaved coprosma

Corallospartium crassicaule:
*coral-broom
sticks (of the shepherds)

Corallospartium racemosum :[1]
coral-broom

Cordyline :
mahonge (= a cultivated variety)
tahanui (= a cultivated variety)

lily-wort

Cordyline australis :
houka (prob. kouka)
kauka
kouka (= tikouka)
kouka tarariki (= a narrow-leaved variety)
kouka wharanui (= a broad-leaved variety)
ti
ti-awe
ti-kauka
ti-kouka
ti-pua
ti-rakau
ti-whanake
whanake

asphodel
cabbage palm

Cordyline australis—cont.
cabbage-palm
cabbage tree
*cabbage-tree
dragon-tree
grass tree
*lily-palm
palm lily
palm-lily
palm tree
te tree
ti palm
ti-ti
ti tree
ti-tree
ti-tri

Cordyline Banksii :
hauora
kapu (= ti-kapu)
ti-kapu
*ti-ngahere
ti-parae
ti-torere

palm-lily
slender cabbage-tree

Cordyline indivisa :
ti-kapu
ti-kupenga
ti-matakutai
ti-toi
*toii

broad-leaf cabbage tree
*broad - leaved cabbage - tree
mountain cabbage-tree
mountain palm

Cordyline pumilio :
mauku
ti-awe
ti-kapu
ti-koraha
ti-kupenga
ti-papa
*ti-rauriki

*dwarf cabbage-tree

Cordyline terminalis :
*ti-pore

dwarf cabbage palm

Coriaria angustissima
annual herbaceous tutu
ground tutu

Coriaria lurida (thymifolia) :
tutuhouhou
tutupapa

Coriaria lucida (thymifolia)—cont.
alpine tutu
ground tutu
mountain tutu
small ground tutu
thyme-leaved tute
*(thymy tutu)

Coriaria sarmentosa (ruscifolia) :
huarua (= the seeds)
puhou
taweku
tupakihi
*tutu

common tute
elder-berry
ink-berry
ruscus-leaved coriaria
toot
toot plant
tree toot
tree tutu
tua-tutu
wine-berry shrub

Coriaria thymifolia. See *C. lurida.*

Corokia buddleoides :[2]
korokio
*korokio-taranga
whakatata

buddleia-like corokia

Corokia Cotoneaster :
cotoneaster-like corokia
mountain-korokio
wiry corokia

Corokia macrocarpa :
hokataka
whakatata

Corynocarpus laevigata :
*karaka
kopi
kopia (= kernels)

cracker
kopi-tree
kraka
laurel
New Zealand laurel
smooth corynocarpus

Corysanthes macrantha :
large-flowered corysanthes
large - flowered spider-orchid
*silverback

[1] Formerly *C. crassicaule* var. *racemosa*.
[2] The name Corokia is from korokio, originally spelt korokia.

Corysanthes rotundifolia :
round - leaved spider-orchid

Cotula atrata :
*black daisy

Cotula coronopifolia :
coronopus-leaved cotula
swamp cotula
swamp-cotula
water-buttons
*yellow-button

Cotula dioica :
salt-meadow cotula
*shore-cotula

Cotula Featherstonii :
mutton-bird plant

Cotula pyrethrifolia :
mountain-cotula

Cotula Traillii :
Stewart Island cotula

Crantzia lineata :
common crantzia

Craspedia minor :
small craspedia

Craspedia uniflora :
puatea

one-flowered craspedia

Crassula moschata :
shore stonecrop
*shore-stonecrop

Cuscuta densiflora :
dense-flowered cuscuta

Cyathea Cunninghamii :
ponga
punui

Cunningham's tree-fern
gully fern (gully-fern in MS.)
*gully-fern
ponja

Cyathea dealbata :
kaponga
katote
*ponga

bunga-bunga
bunger (or bunga)
silver king
silver-king
silver ponga
silver tree-fern
*silver tree-fern
silvery tree-fern
white tree fern

Cyathea kermadecensis :
Kermadec tree-fern

Cyathea medullaris :
korau
*mamaku
mamuku
pitau

black-fern
black tree fern
*black tree-fern

Cyathea Milnei :
Milne's tree-fern

Cyathodes acerosa :
hukihukiraho
inakaporiro
inangaporiro
kukuku
miki
mikimiki
mingi
mingimingi
ngohungohu
patotara
*taumingi
totara
tumingi

prickly styphelia
pungent mingimingi
sharp-leaved heath

Cyathodes robusta :
*rutitira

Chatham mingimingi

Cyclophorus (Polypodium) serpens :
*creeper-fern
thick-leaved polypody
twining polypody

Cystopteris novae-zelandiae (fragilis)
bladder fern
*bladder-fern
brittle bladder fern
brittle bladder-fern
fragile bladder-fern

Dacrydium Bidwillii :
bog pine
bog-pine
mountain pine
*mountain-pine
tar-wood

Dacrydium biforme :
tar-wood
tarwood
*yellow pine
yellow-pine

Dacrydium Colensoi :
manoao

bog pine
golden pine
Hall's totara
*silver pine
silver-pine
tar-wood
Westland pine
Westland silver-pine
white silver pine
yellow pine
yellow-pine

Dacrydium cupressinum :
huarangi (= the fruit)
mapara (= the heart-wood)
ngapara (= the resinous heart-wood)
puaka
*rimu

black pine
drooping pine
giant rimu
New Zealand red pine
*red pine
red-pine
spruce fir
spruce tree

Dacrydium intermedium :
Hall's totara
mountain pine
yellow-pine
*yellow silver pine
yellow silver-pine

Dacrydium Kirkii :
*monoao

Kirk's pine

Dacrydium laxifolium :
rimu

dwarf-pine
loose-leaved dacrydium
mountain rimu
*pigmy pine
pygmy pine

Dacrydium pendulum (nomen nudum)—a variety of *D. cupressinum* :
weeping pine

Dactylanthus Taylori :
pua-o-te-reinga
*puareinga

Danthonia australis :
carpet-grass
*hassock-grass
wiry-leaved oat grass

Danthonia Buchanani :
Buchanan's oat grass
*desert-danthonia

Danthonia crassiuscula :
alpine oat-grass

Danthonia Cunninghamii :
hunangamoho
toetoe-hunangamoho
Cunningham's snow-grass
small-flowered oat tussac grass
tussock oat-grass

Danthonia flavescens :
broad-leaved oat tussac grass
broad-leaved tussock oat-grass
broad-leaved snow-grass
snow grass
*(broad-leaved snowgrass)

Danthonia nuda :
naked oat grass
Thomson's naked oat grass

Danthonia pilosa :
hairy oat-grass
hard oat grass[1]
purple-awned oat grass[1]
*purple-awned oat-grass
racemed oat grass[1]

Danthonia pungens :
bayonet-grass
*(needle-leaved oat-grass)

Danthonia Raoulii :
haumata
narrow-leaved oat tussac grass
red-tussock
snow-grass
*snowgrass

Danthonia Raoulii var. *rubra* :
red-tussock
*(red tussock)

Danthonia semiannularis :
alpine oat grass[2]
common oat-grass
desert oat-grass
dwarf ring grass
New Zealand oat grass[2]
sheep oat grass[2]

Daucus brachiatus :
carrot
native carrot
wild carrot
*(Maori carrot)

Davallia novae zealandiae. See *Leptolepia.*

Dawsonia superba :
*pahau-kakapo
*giant moss

Dendrobium Cunninghamii :
common dendrobe
Cunningham's dendrobium

Deschampsia caespitosa :
tufted hair grass
*tufted hair-grass

Deschampsia Chapmani :
southern hair-grass

Deschampsia tenella :
alpine whorl grass
*(alpine whorl-grass)

Desmoschoenus spiralis (Scirpus frondosus) :
pinao
*pingao
sand-grass
yellow sand-sedge

Deyeuxia (Calamagrostis)

Deyeuxia avenoides :
oat-like bent grass
oat-like bent-grass
*(oat-bent)

Deyeuxia Billardieri :
Billardier's bent grass
sand bent-grass
*(sand-bent)

Deyeuxia filiformis. See *Agrostis Forsteri.*

Deyeuxia filiformis var. *pilosa.* See *Agrostis pilosa.*

Deyeuxia Forsteri. See *Agrostis Forsteri.*

Deyeuxia Petriei :
Australian bent grass

Deyeuxia quadriseta :
spiked bent grass
spiked bent-grass
spiked reed grass
*(spiked bent)

Deyeuxia setifolia :
alpine bent grass
alpine bent-grass
bog bent-grass
*(bog-bent)

Deyeuxia Youngii :
*Mount Cook bent
Young's bent grass

Dianella intermedia :
pepepe
piopio
*rena
turutu
blue berry
*blueberry
intermediate dianella

Dichelachne crinita
long-awned plume grass
long-haired plume-grass
long-hair plume grass
plume-grass
*(long-awned plume)

Dichelachne sciurea :
short-hair plume grass
*(short-awned plume)

Dichelachne stipoides :
wiry dichelachne
*(wiry plume)

Dichondra repens :
common dichondra
creeping dichondra

Dicksonia antarctica :
weki-ponga
southern Dicksonia

Dicksonia fibrosa :
karanuipaka
kuranuipaka
*kuripaka
punui
tukirunga
weki
wheki-kohunga
wheki-ponga
fibrous - stemmed tree - fern
fibrous tree-fern
golden punga
golden tree fern
sturdy tree-fern
woolly tree fern
*(golden tree-fern)

[1] Three varieties of *D. pilosa*.
[2] Three varieties of *D. semiannularis*.

Dicksonia lanata :
stemless tree fern
stumpy tree fern
woolly Dicksonia
woolly tree-fern
*(stemless tree-fern)

Dicksonia squarrosa :
atewheki
pakue
pehiakura
tio
tuakura
tuokura
uruuruwhenua
weki
*wheki

hard tree fern
rough tree-fern
slender dicksonia
*slender tree-fern

Discaria toumatou :
karo
tumatakuri
tumatakuru

Irishman
matagowry
native thorn
New Zealand thorn
prickly thorn
scented thorn
wild Irishman
*wild-irishman

Dodonea viscosa :
ake
*akeake
akerautangi

black akeake
lignum vitæ
lignumvitæ
New Zealand lignum vitæ
viscid dodonea

Donatia novae-zelandiae :
*alpine donatia
common alpine donatia
common donatia
cushion-plant
New Zealand donatia
*(alpine cushion)

Doodia caudata :
mokemoke
mokimoki
*mukimuki

sacred-fern
*scented doodia
tailed doodia

Doodia media :
pukupuku

*large-leaved doodia

Dracophyllum arboreum :
*Chatham tree-heath
tree-heath

Dracophyllum latifolium :
emiemi
*neinei
taritari
taritariawha

broad-leaved grass-tree
grass tree
spider-wood
*spiderwood

Dracophyllum longifolium :
inaka
*inanga

grass tree
grass-tree
long-leaved grass-tree
long-leaved heath
native heath
needle-leaved heath
stunted inaka

Dracophyllum paludosum :
*bog-heath
swamp-heath

Dracophyllum Pearsoni :
Pearson's needle-leaved heath

Dracophyllum politum :
cushion-forming heath

Dracophyllum recurvum :
*red heath

Dracophyllum rosmarinifolium :
prostrate needle-leaved heath

Dracophyllum scoparium :
*fern-strangler

Dracophyllum strictum :
totorowhiti

Dracophyllum subulatum :
*monoao

Dracophyllum Traversii :
mountain neinei
*mountain-neinei

Dracophyllum uniflorum :
one-flowered grass-tree
turpentine-shrub

Dracophyllum Urvilleanum :
*wharekohu

common needle-leaved heath
grass-tree
northern needle-leaved heath
smaller grass-tree

Drapetes Dieffenbachii :
common drapetes

Drapetes Lyallii :
Lyall's drapetes

Drimys. See *Wintera.*

Drosera :
fly-catcher
*sundew

Drosera arcturi :
alpine sun-dew
*alpine sundew
forked sundew

Drosera auriculata :
*climbing sundew
ear-shaped drosera
field sundew

Drosera binata :
fern-flower
fly-catcher
forked-leaved sun-dew
old man's eyebrow
*scented sundew
strap-leaved sundew
twin-leaved drosera

Drosera pygmaea :
pygmy drosera
sun-dew
*(pigmy sundew)

Drosera spathulata :
spathulate-leaved drosera
spoon-leaved sun-dew
*spoon-leaved sundew
sun dew

Drosera stenopetala :
subantarctic sun-dew

Dryopteris (*Nephrodium* and part of *Polypodium*)

Dryopteris cordifolia :
ladder fern
sword-fern
*(ladder-fern)

Dryopteris decomposita :
common boss fern
*(common boss-fern)

Dryopteris dentata (molle) :
soft boss fern
soft buckler-fern
*(soft boss-fern)

Dryopteris glabella :
smooth boss fern
*smooth boss-fern

Dryopteris hispida :
hairy boss fern
hairy fern
hairy-fern
hairy-stemmed fern
hardy-stemmed fern
*(hairy boss-fern)

Dryopteris molle. See *D. dentata.*

Dryopteris pennigera :
pakau-roharoha
piupiu
feather - crowned polypody
*feather-fern

Dryopteris gongylodes (unitum) :
rare boss fern
swamp fern

Dryopteris punctata. See *Hypolepis punctata.*

Dryopteris pustulata. See *Polypodium pustulatum*

Dryopteris Thelypteris var. *squamulosa* :
lady fern
marsh buckler-fern
marsh fern
swamp-fern
*(lady-fern)

Dryopteris unitum. See *D. gongylodes.*

Dryopteris velutina :
dirty fern
velvet boss fern
velvet fern
*(velvet-fern)

Durvillaea antarctica (utilis) :
*rimurapa
*bull-kelp
kelp

Dysoxylum spectabile :
kohe
*kohekohe
kohepi (= the flowers)
maota
cedar
handsome dysoxylum
native cedar
New Zealand cedar

Earina autumnalis :[1]
*raupeka
*fragrant earina
sweet-scented earina

Earina mucronata :
*pekaawaka
pointed-leaved earina
sharp-pointed earina
*(sharp-leaved earina)

Earina suaveolens. See *E. autumnalis.*

Echinopogon ovatus :
rough-bearded grass

Edwardsia. See *Sophora tetraptera*, footnote.

Elaeocarpus dentatus :
*hinau
pokaka
whinau
black hinau
bokako
toothed elaeocarpus

Elaeocarpus Hookerianus :
hinau
mahimahi
*pokaka
whinaupuka
bocarro
bokaka
bokako
white hinau

Elaeocharis acuta :
Australian spike-rush

Elaeocharis Cunninghamii:
Australian spike-rush
slender spike-rush
spike rush

Elaeocharis sphacelata :
kutakuta
*ngawha
paopao
great spike-rush
tall spike-rush

Elatine americana :
American water wort

Elatine americana var. *australiensis* :
water-wort

Elatostema rugosum :
*parataniwha
native begonia
New Zealand begonia
wrinkled elatostema
*(begonia-fern)

Elytranthe (Loranthus) Colensoi :
*korukoru (= when in flower)
pirita
Colenso's mistletoe
scarlet-flowered mistletoe
*scarlet mistletoe

Elytranthe (Loranthus) flavidus :
*yellow mistletoe

Elytranthe tetrapetala (Loranthus Fieldii and *L. tetrapetalis)* :
pikirangi
*pirirangi
four-petalled mistletoe
red mistletoe
*scarlet mistletoe

Enargea parviflora :
*nohi
puwatawata
forest snowberry
*forest-snowberry
marginate luzuriaga
snowberry

Entelea arborescens :
hauama
houama
*whau
whauama
whauma

[1] Now includes also *E. suaveolens.*

Entelea arborescens—cont.
cork tree
cork-wood
corkwood
native cork wood
native mulberry
New Zealand mulberry
shrubby entelea
*(Maori mulberry)

Epacris alpina :
*nehenehe
alpine epacris

Epacris pauciflora :
*tamingi
*bog-epacris
common New Zealand epacris
few-flowering epacris
native heath

Epilobium :
willow-herb
*(willowherb)

Epilobium Billardierianum :
red-stemmed willow-herb

Epilobium chionanthum :
pale-leaved willow-herb

Epilobium chloraefolium :
mountain willow-herb

Epilobium cinereum :[1]
narrow-leaved willowherb

Epilobium crassum :
thick-leaved willow-herb

Epilobium erectum :
tall willowherb

Epilobium glabellum :
glossy-leaved willow-herb

Epilobium insulare :
creeping marsh willow-herb

Epilobium junceum. See *E. cinereum*.

Epilobium linnaeoides :
forest willow-herb

Epilobium macropus :
mountain water-willow-herb

Epilobium microphyllum :
papakoura

Epilobium nerterioides :
wrinkled willow-herb

Epilobium nerterioides var. *minimum* :
short-stemmed willowherb

Epilobium novae-zelandiae :
pale willow-herb

Epilobium nummularifolium :
creeping willow-herb

Epilobium pallidiflorum :
large white willow-herb
swamp willow-herb
*(swamp-willowherb)

Epilobium pedunculare :
long-stalked willow-herb
long-stemmed willowherb

Epilobium pictum :
variegated willow-herb

Epilobium pubens :
soft-leaved willow-herb

Epilobium rotundifolium :
round-leaved willow-herb

Erechtites arguta :
*woolly fireweed

Erechtites diversifolia :
Petrie's fireweed

Erechtites glabrescens :
Kirk's fireweed

Erechtites prenanthoides :
common fireweed
native groundsel
prenanthes-like erechtites

Erechtites quadridentata :
*pekapeka
*white fireweed

Erechtites scaberula :
scabrid fireweed

†*Erigeron canadensis* :
haka
kaingarua
porerarua
pouhawaiki
Canadian flea-bane

Eryngium vesiculosum :
Australian sea-holly
eryngo
sea holly
*(sea-holly)
small sea-holly
vesiculate eryngium

Eugenia maire :
mairetawake
*mairetawhake
puka
tuhuhi
whawhakou
*black maire
red-fruited maire

Euphorbia glauca :
waiuatua (= spirit-milk)
waiu-o-Kahukura (= milk of Kahukura)
caper spurge
glaucous euphorbia
New Zealand spurge
spurgewort
sun spurge
*(Maori spurge)

Euphrasia Cockayniana :
eyebright
*yellow eyebright

Euphrasia cuneata :
tutaekiore
*tutumako
eye-bright
tall eye-bright

Euphrasia Dyeri :
Dyer's eye-bright

Euphrasia Monroi :
*alpine eyebright
eyebright

Euphrasia repens :
shore-eyebright
snowy eye-bright
*(snowy eyebright)

Euphrasia tricolor :
North Island eyebright
*(three-hued eyebright)

Euphrasia zelandica :
antarctic eyebright
eye-bright
New Zealand eyebright
small eyebright
*(Maori eyebright)

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[1] Now includes also *E. junceum*.

Festuca Coxii :
Chatham Island fescue
*(Chatham fescue)

Festuca littoralis :
*hinarepe
matiatia
matihetihe
pouaka

*sand-fescue
sand fescue-grass
sandhill-fescue
sandhill fescue-grass
sand tussock-grass

Festuca ovina var. *novae-zelandiae :*
New Zealand sheep's fescue

Festuca multinodis :
drooping-fescue
*(drooping fescue)

Festuca novae-zelandiae :
*fescue-tussock
hard fescue grass
hard tussock
hard-tussock
tussock-fescue

†*Festuca rubra :*
*red fescue

Forstera sedifolia :
common forstera

Forstera sedifolia var. *oculata :*
large-flowered forstera

Freycinetia Banksii :
*kiekie
patangatanga (= the fruit)
peia
tarapapa (= the flowers)
tawhara (= the flowers)
teure (= the fruit)
tirori (=the fruit)
ureure (=the fruit)

boa
geigei
giegie
gigi
native screw-pine
New Zealand screw-pine
New Zealand's pine-apple
wild pine-apple
*(Maori screw-pine)

Fuchsia Colensoi :
Colenso's fuchsia
shrubby fuchsia
*shrub-fuchsia
slender fuchsia

Fuchsia excorticata :
hona (= the fruit)
kohutuhutu
*kotukutuku
konini (= the fruit)
mati (= the fruit)
takawa (= the fruit)

bucket-of-water wood
fuchsia
fuchsia tree
fuchsia-tree
konini tree
native fuchsia
New Zealand fuchsia
tree fuchsia
*tree-fuchsia

Fuchsia procumbens :
creeping fuchsia
prostrate fuchsia
*shore-fuchsia

Funaria hygrometrica :

Fusanus Cunninghamii. See *Mida salicifolia.*

Gahnia :
mapere
*(cutting grass)

Gahnia gahniaefolia :
cutting grass

Gahnia lacera :
*tarangarara
toetoe-kiwi
toetoe-tarangarara

cutting grass

Gahnia pauciflora :
cutting-grass

Gahnia procera :
South Island gahnia

Gahnia xanthocarpa :
cutting grass
cutting-grass
giant cutting-sedge
*giant gahnia
sedge

Gaimardia ciliata :
*bog-cushion
bog pincushion
bog-pincushion

Galium :
*bedstraw

Galium tenuicaule :
bed straw

Galium umbrosum :
*mawe

New Zealand bed-straw
*(Maori bedstraw)

Gastrodia Cunninghamii :
*huperei
maukuuku
para (= tuber used as food)
perei
uhiperei

Cunningham's gastrodia

Gaultheria antipoda :
koropuka
papapa
takapo
*taupuku
tawiniwini

chuckie chucks (=the fruit)
erect snowberry
native heath
snow berry
snow-berry
*snowberry

Gaultheria depressa :
*mountain-snowberry

Gaultheria oppositifolia :
kama
*niniwa
waiuatua

Gaultheria perplexa :
narrow-leaved snowberry
*wiry snowberry

Gaultheria rupestris :
snow berry
snowberry
*(vale-lily snowberry)

Gaya Lyallii :[1]
hohere (prob. houhere)
whauwhau
whauwhi

giant-flowered southern lacebark
lace bark
lace-bark
lacebark
large-flowered ribbonwood
mountain ribbon-wood
mountain ribbonwood
*mountain-ribbonwood
ribbon tree

Gaya ribifolia :
hoary mountain-ribbon-wood

[1] Now includes also *Plagianthus Lyallii.*

Geniostoma ligustrifolium :
hangehange
*hengahenga
pahengahenga
papa
papahenga
whangewhange
New Zealand privet
privet-leaved geniostoma
*(Maori privet)

Gentiana bellidifolia :
common mountain-gentian
common New Zealand gentian
*mountain-gentian

Gentiana cerina :
*waxy gentian

Gentiana chathamica :
*Chatham gentian
gentian

Gentiana corymbifera :
mountain gentian
*snow-gentian
stupid gentian (hardly a name)

Gentiana Griesbachii :
common New Zealand gentian
March-flowering gentian
small New Zealand gentian

Gentiana lineata :
*tiny gentian

Gentiana montana :
gentian

Gentiana saxosa :
coastal gentian
gentian of the rocks
*shore-gentian
white gentian
white shore-gentian

Gentiana Townsoni :
*bog-gentian
white bog-gentian

Geranium :
crane's bill
cranes'-bill
*cranesbill

Geranium dissectum :
*matuakumara
pinakitere
white carrot

Geranium dissectum var. *australe*. See *G. pilosum*.

Geranium microphyllum :
native geranium
slender cranesbill
slender geranium
small-leaved crane's-bill
*small-leaved cranesbill

†*Geranium molle* :
*namunamu

Geranium pilosum (dissectum var. *australe)* :
*cut-leaved geranium

Geranium sessiliflorum var. *glabrum* :
short-flowered crane's-bill
*short-flowered cranesbill

Geranium Traversii :
*Chatham cranesbill
Chatham Island cranesbill

Geum parviflorum :
avens

Geum uniflorum :
*alpine avens

Geum urbanum var. *strictum (urbanum)* :
kopata
kowhai
common avens
herb bennett

Gleichenia alpina :
alpine tangle-fern
alpine umbrella fern
*alpine umbrella-fern
mountain umbrella-fern

Gleichenia circinata :
mataua-rarauke
matuku
waewaekaka
waewaekotuku
waewaematuku
climbing umbrella-fern
curved tangle-fern
scrambling umbrella fern
scrambling umbrella-fern
tangle-fern
*(cranesfoot) (= waewaekotuku)

Gleichenia Cunninghamii :
rarauheriki
tapuwae-kotuku
*waekura
*bush umbrella-fern
umbrella fern
umbrella-fern

Gleichenia dicarpa :
rarauhe
bog umbrella fern
climbing umbrella-fern
woolly tangle-fern
swamp fern
swamp umbrella fern
tangle-fern

Gleichenia dichotoma :
forked umbrella-fern

Gleichenia flabellata :
fan fern
*fan-fern
fan-leaved fern
fan-like umbrella fern
fan umbrella fern

Glossostigma elatinoides :
elatine-like glossostigma

Gnaphalium :
everlasting
*(cudweed)

Gnaphalium collinum :
hill cudweed
*(hill-cudweed)

Gnaphalium japonicum :
Japanese cudweed

Gnaphalium keriense :
puatea
river daisy
*(river-daisy)

Gnaphalium luteo-album :
pukatea
common cudweed
white cudweed
yellowish-white gnaphalium
*(flannel-leaf)

Gnaphalium Lyallii :
*rock-cudweed

Gnaphalium paludosum :
marsh cudweed
*(marsh-cudweed)

†*Gnaphalium purpureum* :
purple cudweed

Gnaphalium trinerve :
*three-nerved cudweed

Griselinia littoralis :
kapuka
maihiihi
*papauma
paraparauma
tapatapauma

broad leaf
broad-leaf
*broadleaf
New Zealand laurel

Griselinia lucida :
*puka

broad leaf
broadleaf
large broadleaf
shining broadleaf
*(greater broadleaf)

Gunnera albocarpa :
white-fruited gunnera

Gunnera arenaria :
*sand-gunnera

Gunnera dentata :
red-fruited gunnera

Gunnera Hamiltonii :
Southland gunnera

Gunnera monoica :
solitary gunnera

Gunnera prorepens :
creeping gunnera
creeping-gunnera

Gymnogramme leptophylla :
Jersey-fern
*Jersey fern

Gymnogramme rutaefolia :
alpine rue-leaved fern
rue-leaved fern
*(rue-fern)

Haastia pulvinaris :
cushion-like haastia
vegetable sheep
*(giant vegetable-sheep)

Halorrhagis alata :
toatoa

Halorrhagis erecta :
toatoa

erect haloragis
tall haloragis

Halorrhagis incana :
piripiri

heath haloragis.

Halorrhagis micrantha :
piripiri

marsh haloragis

Halorrhagis procumbens (tetragyna) :
piripiri

Hebe (Veronica) amabilis var. *blanda* :
large-flowered veronica

Hebe (Veronica) annulata :
*rock-koromiko

Hebe (Veronica) brevirace-mosa :
*Kermadec koromiko

Hebe (Veronica) buxifolia :
box-leaved koromiko
New Zealand box
*(box-koromiko)

Hebe (Veronica) buxifolia var. *odora* :
box-leaved veronica
New Zealand box
*(globe-koromiko)

Hebe (Veronica) buxifolia var. *prostrata* :
prostrate New Zealand box

Hebe (Veronica) cupres-soides :
*cypress-koromiko

Hebe (Veronica) diosmae-folia .
aute

heath-veronica
shrubby speedwell
*(heath-koromiko)

Hebe (Veronica) elliptica :
coastal veronica
*shore-koromiko
speedwell

Hebe (Veronica) epacridea :
epacris-like veronica
trailing-veronica
*(trailing-koromiko)

Hebe (Veronica) haustrata :
*scoop-leaved koromiko

Hebe (Veronica) Hulkeana :
New Zealand lilac
*(lilac-koromiko)

Hebe (Veronica) Laingii :
Laing's whipcord veronica

Hebe (Veronica) Lavaudi-ana :
Lavaud's veronica

Hebe (Veronica) leiophylla :
smooth-leaved koromiko

Hebe (Veronica) linifolia :
wet-rock koromiko

Hebe (Veronica) lycopodi-oides :
common whipcord koro-miko
lycopodium-like veronica
whipcord veronica
*(whipcord-koromiko)

Hebe (Veronica) monticola :
mountain-loving veronica
*(mountain-koromiko)

Hebe (Veronica) parviflora :
kokomuka-taranga
koromiko-taranga

Hebe (Veronica) salicifolia :
kokomuka
kokoromiko
kokoromuka
koromiko
koromuka

common koromiko
common veronica
New Zealand willow
willow-leaved veronica
*(willow-koromiko)

Hebe (Veronica) salicifolia var. *Atkinsonii* :
Cook Strait koromiko

Hebe (Veronica) speciosa :
*napuka
titirangi

handsome veronica

Hebe (Veronica) subalpina :
subalpine koromiko

Hebe (Veronica) tetragona :
pumice whipcord koro-miko
square-stemmed veronica
whipcord koromiko

Hebe (Veronica) tetrasticha :
semi-whipcord koromiko

Hebe (Veronica) Traversii :
Travers's veronica

Hectorella caespitosa :
tufted hectorella

Hedycarya arborea :
kaiwhiria
poporokaiwhiri
*porokaiwhiria

pigeon-wood
*pigeonwood
tree-like hedycarya

Helichrysum bellidioides :
false edelweiss
mountain daisy
mountain-daisy
native everlasting

Helichrysum coralloides :
coral-shrub

Helichrysum filicaule :
slender everlasting

Helichrysum glomeratum :
niniao

Helichrysum Selago :
selago-like everlasting

Hemitelia Smithii :
katote
neineikura
*whe

green tree-fern
pale-leaved tree-fern
Smith's tree-fern
soft-leaved tree-fern
soft tree fern
*soft tree-fern

Herpolirion novae - zelandiae :
*grass-lily
ground-lily
New Zealand herpolirion
pale-blue grass-lily

Hibiscus trionum :
New Zealand hibiscus
*starry hibiscus

Hierochloe Fraseri :
alpine holy grass
*alpine holy-grass
holy grass

Hierochloe redolens :
*karetu

broad-leaved cattle grass
cutting grass
holy grass
holy-grass
scented grass
sweet-scented holy grass
sweet - scented sacred grass
sweet - scented swamp grass
sweet - scented vernal grass
sweet vernal grass
*(sweet vernal)

Hirneola auricula-Judae :
Jew's-ear fungus
*(ear-fungus)

Hirneola polytricha :
hakeka
hakekakeka
hakeke
hakekeke
hokeke
keka
kekeke
paheke
tarawhata
taringakuri
taringa-o-Tiakiwai

Histiopteris (*Pteris* in part) *incisa :*
matata

cut-leaved bracken
green fern
toothed-leaf bracken
water fern
*water-fern

Hoheria angustifolia :
houhipuruhi

lacebark
*narrow-leaved lacebark

Hoheria populnea :[1]
hohere (prob. houhere)
hoihere
*houhere
houhi
houi
hungere (= small-leafed variety)
whauwhi

lace bark
lace-bark
*lacebark

Hoheria populnea—cont.
lace wood
New Zealand orange-blossom
poplar-like ribbon-wood
ribbon wood
ribbon-wood
ribbonwood
thousand-jacket
thousand jackets

Hoheria sexstylosa :
*long-leaved lacebark

Hydrocotyle americana :
American marsh-pennywort

Hydrocotyle asiatica. See *Centlela uniflora.*

Hydrocotyle dissecta :
cut-leaved marsh pennywort

Hydrocotyle elongata :
long - stemmed marsh - pennywort

Hydrocotyle microphylla :
small - leaved marsh - pennywort

Hydrocotyle moschata :
sharp - toothed marsh - pennywort

Hydrocotyle novae zelandiae:
New Zealand hydrocotyle
New Zealand marsh pennywort
New Zealand marsh - pennywort
*(Maori marsh-pennywort)

Hymenanthera chathamica :
mahoe

*Chatham mahoe

Hymenanthera crassifolia :
thick - leaved hymenanthera

Hymenophyllum :
mauku

filmy ferns
*(filmy fern)

Hymenophyllum Armstrongii :[2]
Armstrong's fern

[1] Popularly these names are given indifferently to all the species of *Hoheria*, not only to *H. populnea*, which is the rarest of them all.
[2] Now includes *H. Cheesemanii.*

Hymenophyllum atrovirens :
mountain broad-leaved filmy fern

Hymenophyllum australe :
crisped filmy fern
Java fern

Hymenophyllum bivalve :
two-valved filmy fern

Hymenophyllum Cheesemanii :[1]
Cheeseman's fern
Cheeseman's filmy fern

Hymenophyllum ciliatum :
fringed filmy fern

Hymenophyllum demissum :
*irirangi
piripiri
carpet fern
*carpet-fern
drooping filmy fern

Hymenophyllum dilatatum :
irirangi
*matuamauku
broad-leaved filmy fern

Hymenophyllum ferrugineum :
rusty filmy fern

Hymenophyllum flabellatum :
fan-leaved filmy fern

Hymenophyllum Malingii :
Maling's fern
silver filmy fern
silvery filmy fern

Hymenophyllum minimum :
little filmy fern

Hymenophyllum multifidum:
sharp-toothed filmy fern

Hymenophyllum peltatum :
one-sided fern

Hymenophyllum polyanthos. See *H. sanguinolentum*.

Hymenophyllum pulcherrimum :
beautiful filmy fern
tufted filmy fern

Hymenophyllum rarum :
thin-leaved filmy fern

Hymenophyllum rufescens :
Field's fern
reddish filmy fern

Hymenophyllum sanguinolentum :[2]
piripiri
scented filmy fern

Hymenophyllum scabrum :
rough-stalked filmy fern

Hymenophyllum tunbridgense :
*Tunbridge fern
Tunbridge-fern
Tunbridge filmy fern

Hymenophyllum villosum :
alpine filmy fern
Colenso's filmy fern

Hypericum gramineum :
St. John's wort

Hypericum japonicum :
Japanese St. John's wort

Hypnum clandestinum :
*wheuwheu

Hypolaena lateriflora :
*wire-rush

Hypolepis distans :
brown hypolepis

Hypolepis Millefolium :
thousand leaves
*thousand-leaves

Hypolepis (Dryopteris) punctata :
hairy polypody
sticky-fern

Hypolepis tenuifolia :
thin-leaved hypolepis

Ileodictyon cibarium. See *Clathrus cibarius*.

Ipomoea batatas :
*kumara
Cultivated varieties—
anurangi
hamo

Ipomoea batatas—cont.
Cultivated varieties—*ctd.*
hawere
hitara
huiupoko
hutihuti
ihupuku
kaikaka
kairorowhare
kakatarahae
kanawa
katoto
kauto
kautowhau
kawakawa
kawakawa-tawhiti
kawau
kengo
kiokiorangi
kirikaraka
kokorangi
konehu
kongungu (= small tubers)
korehorehe
kurarangi
makakauri
makururangi
makutu
maomao
mapua
maramawhiti
marere (used in Maori "pure" ceremony)
matakauri
matawaiwai
mengirangi
moii
monenehu
ngakaukuri
ngakomoa
paea
panahi
pane
papahaoa
parakaraka
paretaua
patea
pauaatahu
pehu
pipiko-kauhangaroa
pohutukawa
pokerekahu
poranga
puatahoe
punuiarata
purata
raumataki
tanehurangi
taputini
taratamata
taurapunga
tetereia

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[1] Name not now recognized; included in *H. Armstrongii*.
[2] Includes *H. polyanthos*.

Ipomoea batatas—cont.
Cultivated varietie. —*ctd.*
toikahikatea
toitoi
toroamahoe
torowhenua
tukou
tutaetara
tutanga
tutuhanga
ururangi
waiha
waina
waniwani
weni
whakakumu

Ipomoea palmata :
panahi
powhiwhi

Isachne australis :
equal-glumed millet

Isotes alpinus :
alpine quillwort

Isotes Kirkii :
*quillwort

Ixerba brexioides :
*tawari
whakou (= the flowers)

brexia-like ixerba
teddywood

Jovellana repens :
creeping New Zealand calceolaria

Jovellana Sinclairii :
New Zealand calceolaria
Sinclair's calceolaria
upright calceolaria
wild calceolaria
*(Maori calceolaria)

Juncus antarcticus :
*antarctic rush

†*Juncus effusus* :
wi
wiwi

Juncus bufonius :
*toad-rush

Juncus lampocarpus :
*jointed rush

Juncus maritimus var. *australiensis* :
wiwi

Australian sea-rush
rush
*sea-rush

Juncus novae-zelandiae :
*alpine rush
rush

Juncus pallidus :
*giant rush

Juncus pauciflorus :
*slender rush

Juncus planifolius :
*flat-leaved rush

Juncus polyanthemos :
wi
wiwi

common rush
rush

Juncus scheuzerioides :
rush

Knightia excelsa :
*rewarewa

honey-suckle
native honey-suckle
New Zealand honeysuckle
river river
ruva-ruva
*(Maori honeysuckle)

Koeleria Kurtzii :
crested hair grass
*(crested hair-grass)

Lagenaria vulgaris :
*hue
pahau (= cultivated variety)
paretarakihi (= cultivated variety)
wenewene (= cultivated variety)
whangai-rangatira (= cultivated variety)

calabash
*gourd

Lagenophora Forsteri :[1]
native daisy

Lagenophora lanata :
hairy native daisy

Lagenophora petiolata :
*parani

native daisy
New Zealand daisy
slender New Zealand daisy

Lagenophora pumila :
*papataniwhaniwha

Forster's lagenophora
native daisy
New Zealand daisy
slender New Zealand daisy
*(Maori daisy)

Lagenophora Thomsoni :
Thomson's daisy

Laurelia novae-zelandiae :
*pukatea

buckerteer
bukitea

Lemna minor :
karearea

duck weed
duck-weed
duckweed
floating duckweed

Lepidium oleraceum var. *acutidentatum* :
eketara
*nau

*Cook's scurvy-grass
scurvy weed

Lepidium sisymbrioides :
*pepperwort

Lepidium tenuicaule :
*shore-cress

Leptocarpus simplex :
*oioi

coastal jointed rush
jointed rush
red rush
yellow rush
*(gold-rush)

Leptolepia novae-zealandiae :[2]
common davallia

Leptopteris (Todea)

[1] Name not now recognized; included in *L. pumila*.
[2] Formerly *Davallia*.

Leptopteris hymenophylloides :
heruheru
mauku
rarauhe

filmy todea
*single Prince of Wales feather
single crape fern
single crape-fern
single crepe fern

Leptopteris superba :
heruheru
huruhuru-o-nga-waewae-o-Paoa
ngutukakariki
ngutungutu
ngutungutukiwi
punui
tete

chenille fern
crape fern
crape-fern
double crape fern
double crape-fern
double velvet fern
glory of the west
hot-water fern
king's fern
moss fern
*Prince of Wales feather
Prince of Wales' feather
Prince of Wales's feather
royal fern
velvet fern

Leptospermum Chapmanii :
pink-flowered manuka
red-flowered manuka

Leptospermum ericoides :
*kanuka
kopuka
manuka-rauriki
maru
rauwiri

bush manuka
heath-like manuka
red-manuka
scrub manuka
small-leaved manuka
tea tree
tea-tree
teatree
ti tree
tree manuka
*tree-manuka
white manuka
white tea-tree

Leptospermum Nichollsii :[1]
crimson-flowered manuka
*crimson manuka

Leptospermum scoparium :
kahikatoa
kaitatoa
katoa
*manuka
pata
piamanuka (=mannalike exudation)
rauwiri

gadoa
heath
manuka broom
red manuka
red tea-tree
tea plant
tea tree
ti tree
ti-tree
titree
tree manuka

Leucogenes (Helichrysum) grandiceps :
edelweiss
New Zealand edelweiss
South Island edelweiss

Leucogenes Leontopodium :
New Zealand edelweiss
North Island edelweiss
*(Maori edelweiss)

Leucopogon fasciculatus :
hukihukiraho
kaikaiatua
mingi
mingimingi
ngohungohu
tumingi

bundle-flowered leucopogon
tall bearded heath
tall mingimingi

Leucopogon Fraseri :
patotara
totara
totarapapa
totaraparae
totaratahuna

dwarf bearded heath
*dwarf heath
Frazer's leucopogon

Leucopogon Fraseri—cont.
heath
native heath
prickly heath
pungent heath
sharp-leaved heath
small sharp-leaved heath

Libertia grandifolia :
turutu

large-flowered libertia

Libertia ixioides :
mangahuripapa
*mikoikoi
tukauki
turutu

common libertia
ixia-like libertia
native iris
*(ixia-libertia)

Libertia pulchella :
forest libertia
*(forest-libertia)

Libocedrus Bidwillii :
*pahautea

Bidwill's libocedrus
cedar
incense cedar
kawaka cedar
mountain cedar
mountain-cedar
native cedar
native cypress
New Zealand cypress
silver pine

Libocedrus Doniana :
kahikawaka
kaikawaka
*kawaka
mokopiko
totara-kiri-kotukutuku

bastard totara
cedar
cypress
New Zealand arbor vitae
New Zealand arbor-vitæ
New Zealand cedar
New Zealand cypress

Ligusticum. See *Anisotome*.

Lindsaya cuneata (L. microphylla and *L. trichomanoides)* :
broad-leaved lindsaya
small-leaved lindsaya

[1] This is purely a garden plant. The one wild plant discovered with crimson flowers was transplanted but died. From it seed were saved; when sown one crimson-flowered plant was produced, and cuttings from it have given rise to the plants known as *L. Nichollsii*.

Lindsaya linearis :
narrow-leaved lindsaya
narrow lindsaya

Lindsaya microphylla. See *L. cuneata.*

Lindsaya trichomanoides. See *L. cuneata.*

Lindsaya viridis :
green lindsaya

Linum monogynum :
kaho
matamatahuia
nao
*rauhuia
flax
native flax
perennial flax
true New Zealand flax
white flax
white-flowered flax
*(tinker-bell)

Litsaea calicaris :
*mangeao
punui
tangeao
tangeo

Lobelia anceps :
common New Zealand lobelia
doubtful lobelia
*shore-lobelia

Lobelia Roughii :
fleshy-leaved lobelia

Lomaria. See *Blechnum.*

Loranthus :
native mistletoe
*(Maori mistletoe)

Loranthus Colensoi. See *Elytranthe Colensoi.*

Loranthus flavidus. See *Elytranthe flavidus.*

Loranthus micranthus :
common mistletoe
common New Zealand mistletoe
loranth
mistletoe
small-flowered mistletoe

Loranthus tetrapetalis. See *Elytranthe tetrapetala.*

Loxsoma Cunninghamii :
loxsoma fern
*silver-green fern

Luzula campestris :
*wood-rush

Luzula Traversii (racemosa) :
wood-rush

Luzuriaga. See *Enargea.*

Lycopodium :
*club-mosses

Lycopodium Billardieri :
*iwituna
whiri-o-Raukatauri
hanging club-moss
pendulous club-moss
pendulous lycopodium

Lycopodium cernuum :
creeping club-moss

Lycopodium densum :
puakarimu
waewaekoukou
tree club-moss

Lycopodium Drummondii :
Australian club-moss

Lycopodium fastigiatum :
alpine club-moss
small mountain club-mo[ss]

Lycopodium laterale :
bog club-moss

Lycopodium ramulosum :
club-moss
matted club-moss

Lycopodium scariosum :
creeping club-moss
mountain club-moss

Lycopodium Selago :
fir club-moss

Lycopodium varium :
nodding club-moss

Lycopodium volubile :
waekahu
waewaekoukou
antler fern
climbing club-moss
giant lycopodium
*(antler-fern)

Lygodium articulatum :
makaka
*mangemange
mangi mangi
mounga
tarikupenga
climbing fern
climbing-fern
climbing flowering fern
*flowering fern
twining string fern

Macropiper excelsum :
kawa
*kawakawa
takawa (= the fruit)
lofty pepper
native pepper
pepper tree
tall pepper-tree
true pepper

Marattia fraxinea :
mouku
*para
parareka
paratawhiti
uwhipara
ash-leaf fern
horseshoe fern
horse-shoe fern
king fern
king-fern
*(horseshoe-fern)

Mariscus ustulatus :
toetoe
toetoe-upokotangata
toetoe-whatumanu
upokotangata
cutting-grass
cutting toe-toe
mariscus-sedge

Mazus pumilio :
dwarf false musk
dwarf mazus

Melicope simplex :
*poataniwha
simple-leaved melicope

Melicope ternata :
houkumara
koheriki
tataka
*wharangi
wharangipiro
lemon-wood
ternate-leaved melicope

Melicytus lanceolatus :
kaiweta
*mahoewao
taranga

lance-leaved whitewood
narrow-leaved hinehine

Melicytus macrophyllus :
large-leaved whitewood

Melicytus micranthus :
*manakura

twiggy whitewood

Melicytus ramiflorus :
hinahina
inihina (prob. inaina)
*mahoe
moeahu

branch-flowered melicytus
cowleaf
cow-tree
white-wood
*whitewood
whiteywood

Mentha Cunninghamii :
hioi
mokimoki

mint
native mint
New Zealand mint
*(Maori mint)

Meryta Sinclairii :
puka

cabbage-tree
*(paddle-leaf)

Mesembryanthemum :
pig-face

Mesembryanthemum australe :
*horokaka
ngarangara
ruerueke

fig marigold
fig-marigold
fig-marygold
ice-plant
native ice-plant
New Zealand ice-plant
pig-face
pig's face
pig's-face
pigs-face
pigsface
pigs' faces

Mesembryanthemum australe—cont.
pink-flowered mesembryanthemum
southern mesembryanthemum
*(Maori ice-plant)

†*Mesembryanthemum edule :*
*Hottentot fig

Metrosideros :
rata-vine

Metrosideros albiflora :
*akatea

white climbing rata
white climbing-rata
white-flowered rata
white-flowering rata
white rata

Metrosideros Colensoi :
hairy climbing-rata

Metrosideros diffusa :
*akakura

crimson climbing-rata

Metrosideros florida. See *M. scandens (florida).*

Metrosideros hypericifolia :
common climbing-rata
hypericum-leaved rata
iron wood
slender climbing white rata
slender climbing white-rata
white climbing rata
white rata

Metrosideros lucida :
rata

ironbark
iron wood
iron-wood
ironwood
mountain rata
mountain-rata
native teak
northern rata
shining rata
shrub rata
southern ironbark
Southern Island rata
southern rata
stunted southern rata

Metrosideros perforata (scandens) :
aka
*aka-torotoro
koro
torotoro
whakapiopio

box rata
climbing rata
climbing white rata
clinging climbing-rata
myrtle
round-leaved climbing rata
small-leaved climbing rata
white rata

Metrosideros robusta :
rata

female pohutukawa
inland pohutukawa
ironwood
New Zealand oak-elm
northern rata
North Island rata
parasite-myrtle
rattar
red tree rata

Metrosideros scandens.[1] See *M. perforata.*

Metrosideros scandens (florida) :
aka
aka-kura
*aka-tawhiwhi
amaru
kahikahika
pua-tawhiwhi
rata
rata-piki
whakatangitangi

climbing red rata
florid rata
flowery rata
giant rata
large-leaved climbing rata
rata vine
red climbing-rata
scarlet climbing-rata
vegetable boa-constrictor

Metrosideros scandens (florida) var. *aurata :*
golden rata

[1] The original *M. scandens* is now *M. perforata*, and the contemporary *M. florida* is now *M. scandens.* This change has inextricably confused the application of the popular names — an application hitherto so lucid.

Metrosideros tomentosa :
hutukawa
*pohutukawa
Christmas flower
*Christmas tree
Christmas-tree
downy ironheart
downy rata
New Zealand ash
New Zealand Christmas tree

Metrosideros villosa :
Kermadec pohutukawa
small-leaved pohutukawa

Microlaena avenacea :
bush oat-grass
bush rice grass
*bush rice-grass
forest rice-grass

Microlaena polynoda :
knot-jointed rice grass
*knotted rice-grass
native bamboo

Microlaena stipoides :
patiti
meadow rice grass
*meadow rice-grass

Microtis porrifolia :
onion-leaved microtis
*onion-leaved orchid

Microtis unifolia :
maikaika
onion-leaved orchid

Mida salicifolia (Fusanus Cunninghamii) :
maire
maire taiki
*taiko
Cunningham's sandal-wood
native sandalwood
New Zealand sandal-wood
New Zealand sandalwood
sandal-wood
*(Maori sandalwood)

Mimulus repens :
large monkey-flower
musk
New Zealand musk
*(Maori musk)

Montia fontana :
water blink
water chickweed
*water-chickweed

Muehlenbeckia :
*wiggybush

Muehlenbeckia adpressa :[1]
black vine
climbing lignum
close-fitting muehlenbeckia

Muehlenbeckia Astoni :
shrubby pohuehue

Muehlenbeckia australis :[2]
puka
broad-leaved puhepuhe
large-leaved pohuehue
Maori-vine
willow plant

Muehlenbeckia axillaris :
axillary-flowered mühlenbeckia
creeping-pohuehue

Muehlenbeckia complexa :
*pohuehue
tororaro
waekahu
clasping mühlenbeckia
slender muehlenbeckia

Myoporum laetum :
*ngaio
gnaio
gnais
native laurel
wild mangrove

Myosotidium hortensia (nobile) :
kopukapuka
kopakopa
Chatham Island lily
Chatham Islands lily
Chatham-Islands lily
giant forget-me-not
Macquarie cabbage
*(Chatham forget-me-not)

Myosotis albida :
coast forget-me-not
shore forget-me-not
white forget-me-not

Myosotis australis :
*yellow forget-me-not

Myosotis capitata :
capitate forget-me-not

Myosotis Forsteri :
forget-me-not
Forster's forget-me-not

Myosotis macrantha :
bronze forget-me-not

Myosotis pygmaea var. *Traillii* :
forget-me-not
small-flowered forget-me-not

Myosotis saxatilis :
rock forget-me-not

Myosotis spathulata :
forget-me-not
spathulate-leaved myosotis
spoon-leaved forget-me-not

Myosotis Traversii :
mountain forget-me-not

Myosurus novae-zealandiae (aristatus) :
*bearded mousetail

Myriophyllum :
*water-milfoil

Myriophyllum elatinoides :
common water-millfoil
elatine-like myriophyllum
native water milfoil
water milfoil
water-milfoil

Myriophyllum robustum :
stout water-milfoil

Myriophyllum Votschii :
small water-milfoil

Myrsine Urvillei. See *Suttonia australis*.

[1] Name not now recognized; included in *M. australis*.
[2] Now includes *M. adpressa*.

Myrtus bullata :
*ramarama

blistered-leaved myrtle
bush myrtle
embossed myrtle
ironwood
myrtle
native myrtle
New Zealand myrtle
rum-a-rum

Myrtus obcordata :
*rohutu
tuhuhi

ironwood
mouse ear
myrtle
native myrtle
obcordate-leaved myrtle

Myrtus pedunculata :
rohutu

pedunculate myrtle
small-leaved myrtle

× *Myrtus Ralphii* :
small-leaved ramarama

Myxomycetes :
*slime-fungi

Nasturtium. See *Radicula.*

Nephrodium. See *Dryopteris.*

Nertera depressa :
fruiting duckweed
oblate-berried nertera

Nertera dichondraefolia :
dichondra-leaved nertera

Nothochlaena distans :
hairy cloak fern
woolly cloak fern
woolly cloak-fern

Nothofagus :
beech
southern-beech
*(Maori beech)

Nothofagus apiculata :
pointed-leaved beech

× *Nothofagus Blairii* :
Blair's beech

Nothofagus cliffortioides :
tawhai-rauriki

black birch
black-birch
cliffortia-like beech
mountain beech
*mountain-beech
mountain birch
mountain southern-beech
white birch
white-birch

Nothofagus fusca :
hutu
hututawai
tawai
tawhai
tawhai-raunui

black beech
black birch
blackpine
bull birch
dusky beech
large leaved birch
red beech
*red-beech
red birch
red-birch
red kamai
red southern-beech
tall red southern-beech
tooth-leaved beech

Nothofagus Menziesii :
tawai
tawhai

beech
brown birch
clinker birch
Menzie's beech
native beech
red birch
round-leaved beech
silver beech
*silver-beech
silver birch
silver southern-beech
white birch
white-birch
white kamai

Nothofagus Solandri :
tawai-rauriki
tawhai
tawhai-rauriki

black beech
*black-beech
black birch
black-heart birch
black southern-beech
brown birch
entire-leaved beech
red birch

Nothofagus Solandri—cont.
silver-birch
Solander's beech
white beech
white birch
yellow birch

Nothofagus truncata :
*clinker-beech

Nothopanax anomalum :
wawaupaku

anomalous nothopanax
shrubby panax
supra-divaricating whau-whaupaku

Nothopanax arboreum :
houhou
parapara
*puahou
whauwhau
whaupaku
whauwhaupaku

black ash
common ivy-tree
five-finger
five-fingered Jack
*ivy-tree
shittimwood

Nothopanax Colensoi :
*orihou

Colenso's nothopanax
gum tree
ivy tree
ivy-tree
*mountain ivy-tree
mountain panax
New Zealand gum tree

Nothopanax Edgerleyi :
haumangoroa
houmangaroa
homanoroa (prob. houmanoroa)
koare
koareare
*raukawa
rauraua

Edgerley's nothopanax
Edgerley's panax
lemon-wood
orange wood
*orange-wood

Nothopanax lineare :
narrow-leaved nothopanax

× *Nothopanax parvum* :
small-leaved panax

Nothopanax simplex :
*haumakoroa
haumangoroa
kaiwiria
simple - leaved nothopanax
simple-leaved panax

Nothopanax Sinclairii :
mountain panax
Sinclair's panax

Notospartium Carmichaeliae :
pink broom

Notospartium torulosum :
New Zealand pink broom

Notothlaspi rosulatum :
pen-wiper plant
penwiper plant
*penwiper-plant
rosette-like notothlaspi
rosette plant

Olea :
New Zealand olive
*(Maori olive)

Olea apetala :
black maire
*broad-leaved maire
ironwood
New Zealand olive

Olea Cunninghamii :
*maire
maire-raunui
black maire
black-maire
cedar
marie
New Zealand sandal-wood
white maire

Olea lanceolata
maire
maire raunui
black maire
*white maire
white-maire

Olea montana
maire kotae
maire roro
maire rauriki
*rororo
narrow leaved maire
narrow-leaved maire

Olearia :
daisy tree
*daisy-tree
tree-daisy

Olearia albida :
Auckland tree-daisy

Olearia angustifolia :
*teteaweka
daisy-tree
purple-flowered daisy-tree

Olearia arborescens (nitida) :
daisy-tree
glossy-leaved daisy-tree
glossy tree-daisy
shining olearia

Olearia avicenniaefolia
akeake
avicennia-leaved olearia
*mountain-akeake

Olearia chathamica :
*keketerehe
Chatham tree-daisy
*(Chatham daisy-tree)

Olearia Colensoi :
kumarahou
*tupare
Colenso's daisy-tree
common mountain tree-daisy
large-leaved tree-daisy
mountain tree-daisy
musk-tree
mutton bird scrub
mutton-bird scrub
mutton-bird-wood
*mutton-wood

Olearia Cunninghamii. See *O. rani.*

Olearia cymbifolia :
boat-leaved tree-daisy

Olearia divaricata :
divaricate tree-daisy
stiff-branched daisy-tree

Olearia excorticata :
fuchsia-barked olearia

Olearia Forsteri. See *O. paniculata.*

Olearia fragrantissima :
fragrant tree-daisy

Olearia furfuracea :
*akepiro
kumara-kai-torouka
tanguru
wharangipiro
bran-like olearia
daisy-tree

Olearia Hectori :
thin-leaved tree-daisy

Olearia ilicifolia :
hakeke
holly-leaved olearia
*Maori holly
mountain-holly
native holly
New Zealand holly

Olearia insignis. See *Pachystegia insignis.*

Olearia lineata :[1]
twiggy tree-daisy

Olearia Lyallii :
tupari
antarctic tree-daisy
subantarctic tree-daisy

Olearia, macrodonta :
*arorangi
wharangikuria
false mountain-holly
false New Zealand holly
large-toothed olearia
native holly

Olearia moschata :
musky olearia
musky tree-daisy
*(musky daisy-tree)

Olearia nummularifolia :
hard-leaved tree-daisy
small-leaved tree-daisy

Olearia odorata :
odorous tree-daisy

Olearia operina :
tupari

Olearia paniculata (Forsteri) :
akepirau
*akiraho

[1] Now includes *O. virgata* var. *lineata.*

Olearia paniculata (Forsteri)—cont.
Forster's daisy-tree
Forster's olearia
golden akeake
golden-akeake
rock-akeake
yellow akeake

Olearia rani (Cunninghamii) :
akewharangi
*heketara
ngungu
taraheke
wharangipiro
forest daisy-tree

Olearia semidentata :
hangatare
*makora
Chatham Island aster
purple-flowered tree-daisy
purple tree-daisy
toothed olearia

Olearia Solandri :
coastal daisy-tree

×*Olearia Traillii* :
Traill's daisy-tree

Olearia Traversii :
akeake
bastard sandal-wood tree
bastard sandalwood tree
*Chatham akeake
Chatham Island akeake
sandalwood
silver akeake

Olearia virgata :
swamp tree-daisy
twiggy daisy-tree
twiggy olearia
*(swamp daisy-tree)

Olearia virgata var. *lineata* :[1]
slender daisy-tree

Ophioglossum :
adder's-tongue

Ophioglossum coriaceum :
adder's-tongue

Ophioglossum lusitanicum :
large adder's tongue
little adder's tongue
little adder's-tongue
narrow adder's tongue
narrow-leaved adder's tongue

Ophioglossum vulgatum :
adders' tongue
adder's tongue fern
adder's-tongue fern
common adder's tongue
*(adders-tongue)

Oplismenus undulatifolius :
slender panic-grass
slender panick grass

Oreobolus pectinatus :
common oreobolus

Oreobolus strictus :
narrow-leaved oreobolus

Orthoceras Solandri :
*ikaika
Solander's orthoceras

Orthoceras strictum :
maikaika
*mamaika
para (=tuber used as food)
paratawhiti

Ourisia caespitosa :
creeping mountain-foxglove
creeping ourisia
tufted ourisia

Ourisia Colensoi :
Colenso's ourisia

Ourisia glandulosa :
glandular ourisia

Ourisia macrocarpa :
snowy mountain-foxglove

Ourisia macrophylla :
hue-o-Raukatauri
alpine foxglove
large-leaved ourisia
*mountain-foxglove
mountain primula
Mount Egmont primula

Ourisia modesta :
tiny ourisia

Ourisia prorepens :
Petrie's ourisia

Ourisia sessilifolia :
hairy ourisia

Oxalis corniculata :
creeping yellow wood-sorrel
horned oxalis
wood-sorrel
*yellow oxalis

Oxalis lactea (magellanica) :
tutaekaahu
Magellan's oxalis
sorrelwood
*white oxalis
white sorrel
wood-sorrel

Pachycladon novae-zelandiae :
New Zealand pachycladon

Pachystegia (Olearia) insignis :
mountain daisy
remarkable olearia
rock tree-daisy
*(rock daisy-tree)

Paesia (Pteris) scaberula :
matata
carpet fern
hard fern
lace fern
lace-fern
*rough bracken
scented fern
slender bracken

Paratrophis Banksi :[2]
coast milk-tree

Paratrophis heterophylla :
ewekuri
pukariao
towai
*turepo

Paratrophis microphylla :
milk tree
*milk-tree
milk-wood
milkwood

Paratrophis opaca :[3]
*large-leaved milk-tree

[1] Name not now recognised; included in *O. lineata*.
[2] Name not now recognised; included in *P. opaca*.
[3] Now includes *P. Banksi*.

Paratrophis Smithii :
*Three Kings milk-tree

Parietaria debilis :
pellitory
weak-stemmed parietaria

Parsonsia capsularis :
akakaikiore
*akakiore
kaiku
kaiwhiria
totoroene

capsulate parsonsia
rosy New Zealand jasmine
small-flowered New Zealand jasmine

Parsonsia capsularis var. *rosea* :
pink New Zealand jasmine
*(pink akakiore)

Parsonsia heterophylla :
akakaikiore
*kaihua
kaiku
kaiwhiria
tawhiwhi

New Zealand jasmine
varied-leaved parsonsia
*(Maori jasmine)

Paspalum distichum :
*sea-side millet

Paspalum scrobiculatum :
tarakoi
*taranui
tuhui

ditch millet
*(ditch-millet)

Passiflora. See *Tetrapathaea*.

Pelargonium australe :
kopata
pukupuku

Pellaea falcata :
hook-leaved black fern

Pellaea rotundifolia :
tarawera

round-leaved fern

Pennantia corymbosa :
hine-kaikomako
kahikomako
*kaikomako

bridal tree
corymbose pennantia
*Maori fire
ribbon-wood
ribbonwood
smutwood

Pentachondra pumila :
little mountain-heath

Peperomia Urvilleana :
D'Urville's peperomia

Persoonia toru :
mihimihi
toro
*toru

Phebalium nudum :
*mairehau
maireire

aromatic-leaved maireire
naked phebalium

Phormium Colensoi (Cookianum) :[1]
korari-tuauru
*wharariki

hill flax
*hill-flax
mountain flax
mountain-flax
New Zealand flax

Phormium tenax :
*harakeke
harapere
harareke
kauhangaroa
korari (=flower-stalk)
kurawaka (= seed-capsule)
Varieties—
aoanga (variegated)
aohanga (variegated)
aorangi (striped)
atemango
ateraukawa
atewheke
awanga (variegated)
hurahura-hika
maomao
oue
parekoritawa (variegated)
paritaniwha
pikoko
potango
rataroa

Phormium tenax—cont.
Varieties—*cont.*
rerehape
rongotainui
rukutia
taiore
takirikau (strong-fibred varieties)
taneawai (bronzy foliage)
tapoto (strong-fibred varieties)
taroa
tihore (very strong fibre)
tika (ordinary varieties)
wharanui

flag
*flax
flax lily
flax-lily
hemp
koradi
native flax
native hemp
New Zealand flax
New-Zealand flax
New Zealand flax-plant
*(Maori flax)

Phyllachne clavigera :
club-leaved phyllachne

Phyllachne Colensoi :
Colenso's phyllachne
common phyllachne

Phyllocladus alpinus :
alpine celery pine
alpine celery-pine
celery-leaved pine
celery pine
celery topped pine
celery-topped pine
mountain celery pine
mountain celery-pine
mountain toatoa
mountain-toatoa
mountain totoa
New Zealand hickory
pitch pine
*(alpine toatoa)

Phyllocladus glaucus :
*toatoa

celery-pine

Phyllocladus trichomanoides :
ahotea
niko
*tanekaha
tawaiwai
toatoa

[1] *P. Cookianum* is now included in *P. tenax*.

Phyllocladus trichomanoides—cont.
celery-leaved pine
celery-pine
celery-topped pine
celery top pine
New Zealand pitch pine
pitch pine

Pimelea arenaria :
aute-taranga
*aute-tauranga
toroheke

*sand-pimelea

Pimelea buxifolia :
box-leaved pimelea

Pimelea laevigata. See *P. prostrata*.

Pimelea longifolia :
koromiko-taranga
*taranga

long-leaved pimelea
New Zealand daphne
*(Maori daphne)

Pimelea Lyallii :
Lyall's pimelea

Pimelea prostrata (laevigata) :
*pinatoro
wharengarara

common pimelea
creeping pimelea
native thyme
smooth pimelea
Strathmore weed (?)

Pimelea virgata :
twiggy pimelea

Piper excelsum. See *Macropiper*).

Pisonia Brunoniana :
*parapara
puhaureroa
puwhaureroa

bird-catcher
bird-catcher plant
bird catching plant
*bird-catching-plant

Pittosporum Colensoi :
rautawhiri

black mapau
Colenso's pittosporum
maple

Pittosporum cornifolium :
karo
*tawhirikaro
wharewhareatua

cornel - leaved pittosporum
perching-kohuhu
straggling pittosporum

Pittosporum crassifolium :
kaikaro
*karo
kihihi

thick-leaved pittosporum
turpentine tree

Pittosporum eugenioides :
kihihi
*tarata

black mapau
citron
eugenia-like pittosporum
lemon matipo
lemon-tree
lemon wood
lemon-wood
*lemonwood
maple
mapu
New Zealand oak
turpentine
turpentine tree
white mapau
white maple

Pittosporum Fairchildii :
*Three Kings karo

Pittosporum Kirkii :
Kirk's pittosporum
thick-leaved kohuhu

Pittosporum obcordatum .
cohou-cohou
obcordate-leaved pittosporum
small-leaved kohuhu

Pittosporum Ralphii :
Ralph's pittosporum

Pittosporum rigidum :
shrubby pittosporum
weeping-matipo

Pittosporum tenuifolium :
kaikaro
*kohuhu
kohukohu
koihu
kowhiwhi
mapauriki
powhiri
rautawhiri

Pittosporum tenuifolium—cont.
tawhiri
tawhiwhi

black birch
black mapau
black maple
black mapou
bucket-of-water-wood
maple
silver birch
small-leaved tarata
thin-leaved pittosporum
turpentine tree

Pittosporum tenuifolium var. *variegata* :
silver matipo
*(silvery kohuhu)

Pittosporum umbellatum :
*haekaro

Plagianthus betulinus :
houi
*manatu
whauwhi

birch-like ribbon-wood
lace-bark tree
lacebark
lowland ribbonwood
ribbon tree
ribbon-tree
ribbon wood
ribbon-wood
ribbonwood
South Island ribbon wood
*(lowland-ribbonwood)

Plagianthus chathamicus :
*Chatham ribbonwood

× *Plagianthus cymosus* :
hybrid ribbonwood

Plagianthus divaricatus :
makaka

salt-marsh ribbonwood
shrubby ribbonwood
wide - branched ribbonwood

Plagianthus Lyallii :[1]
alpine ribbonwood
lace bark
lace-bark
lace bark tree
mountain ribbonwood
ribbon-scrub
ribbon wood
West Coast ribbonwood
wild cherry

[1] Name not now recognized; included in *Gaya Lyallii*.

Plantago :
parerarera

Plantago Brownii :
Brown's plantain

Plantago Hamiltonii :
glossy plantain

Plantago lanigera :
plantain

Plantago Raoulii :
kopakopa

common New Zealand plantain
New Zealand plantain
Raoul's plantain
*(Maori plantain)

Plantago spathulata :
kauparerarera

Pleurophyllum criniferum :
hairy pleurophyllum

Pleurophyllum speciosum :
handsome pleurophyllum
*(goblet-aster)

Poa acicularifolia :
needle-leaved poa

Poa anceps :
broad-leaved poa
nodding plumed poa

Poa anceps var. *breviculmis* :
hard short-stemmed poa

Poa anceps var. *debilis* :
slender poa

Poa anceps var. *densiflora* :
dense-flowered poa

Poa anceps var. *elata* :
nodding plumed poa

Poa Astoni :
seashore poa

Poa breviglumis :
short-glumed poa

Poa caespitosa :
wi

common tussock-grass
silver-tussock
tussac poa
tussock
tussock grass
yellow tussock
*(silver tussock)

Poa chathamica :
*bog-poa

Poa Colensoi :
*blue tussock
blue-tussock
blue tussock-grass
Colenso's poa

Poa exigua :
little poa

Poa foliosa :
Auckland Islands poa[1]
large-flowered poa[1]
minute poa[1]
short-flowered meadow grass
southern islands poa
*tussock-grass

Poa imbecilla :
weak poa
weak-stemmed poa

Poa intermedia (*Colensoi* var. *intermedia*) :
mountain tussock grass
small tussac poa

Poa Kirkii :
Kirk's poa

Poa Kirkii var. *Mackayi* :
brown mountain poa

Poa Lindsayi :
brown-flowered poa

Poa litorosa :
poa-like fescue

Poa novae-zealandiae :
large flowered poa
large-flowered poa

Poa pusilla :
minute creeping poa
slender poa

Poa pygmaea :
dwarf poa

Poa sclerophylla :
white-flowered poa

Poa uniflora :
one-flowered poa

Podocarpus acutifolius :
acute-leaved totara
sharp-leaved totara

Podocarpus dacrydioides :
kahika
*kahikatea
kaikatea (prob. kahikatea)
kapara (= the resin)
katea
koroi (= the fruit)
mapara (= the heart-wood)

dacrydium-like podocarpus
swamp pine
white pine
white-pine
yellow pine

Podocarpus ferrugineus :
*miro
toromiro

black pine
black-pine
rusty podocarpus

Podocarpus Hallii :
alpine totara
*fuchsia-barked totara
large-leaved totara
thin-bark totara
mountain-totara
thin-barked totara

Podocarpus nivalis :
tauhinu

alpine totara
creeping totara
mountain totara
*mountain-totara

Podocarpus spicatus :
kai
kakai (= the young form)
mai
*matai

black pine
black-pine
black rue
black rue pine
red pine
spiked podocarpus

Podocarpus totara :
amoka
mauri (= dark-coloured timber)
*totara
tuanui (= a variety)

[1] Given as three varieties in Buchanan's *Indigenous Grasses of New Zealand.*

Podocarpus totara—cont.
fir
mahogany pine
mahogany-pine
New Zealand mahogany pine
New Zealand yew
red pine
totara pine
totarro

†*Polygonum aviculare* :
makakaka

Polygonum serrulatum :
*tutunawai

water persicaria

Polypodium Billardieri :[1]
hound's tongue
narrow-leaved polypody
*hounds-tongue

Polypodium dictyopteris (Cunninghamii) :
Cunningham's polypody

Polypodium diversifolium :[2]
kowaowao
*maratata
paraharaha
raumanga

Billardier's polypody
*climbing polypody
climbing-polypody
common climbing polypody
common climbing-polypody
common polypody
narrow-leaved polypody

Polypodium grammitidis :
saw-edged polypody

Polypodium novae-zealandiae :
giant polypody

Polypodium pumilum :
dwarf polypody

Polypodium pustulatum (Dryopteris pustulata) :
mokimoki

scented polypody
fragrant-fern

Polypodium. See also *Dryopteris.*

Polystichum :
shield fern
*(shield-fern)

Polystichum aculeatum :[3]
puniu

Polystichum adiantiforme :
climbing shield fern
thick-leaved shield fern
thick-leaved shield-fern

Polystichum aristatum :[4]
awned shield fern

Polystichum cystostegium :
alpine fern
alpine shield fern
alpine shield-fern
Egmont fern
snow shield fern

Polystichum oculatum :[5]
long-stalked shield fern
spotted shield fern
*(argus shield-fern)

Polystichum Richardi :[6]
pikopiko
*pipiko
tutoke

black shield fern
black shield-fern
hard shield-fern
Richards' shield fern

Polystichum vestitum :[7]
prickly shield fern
prickly shield-fern

Polytrichum dendroides :
tree-moss

Pomaderris apetala :
nonokia
*tainui

ti mi

Pomaderris Edgerleyi :
kumarahou

Pomaderris elliptica :
kumarahou
papapa

dwarf tainui
elliptical-leaved pomaderris
yellow tainui

Pomaderris phylicaefolia :
taihinu
*tauhinu

cotton wood
heath-like pomaderris
heath-like tainui
phylica-leaved pomaderris

Potamogeton :
pond-weed
*pondweed

Potamogeton Cheesemanii :
*manihi
rerewai

Cheeseman's pond-weed
common New Zealand pondweed
common pond-weed
*(Maori pondweed)

Potamogeton natans :
manihi
*rerewai

pond weed
pond-weed

Potamogeton polygonifolius :
persicaria-leaved pondweed

Potentilla anserina :
silver-weed

Potentilla anserina var. *anserinoides* :
*kowhaikura

*silverweed

Pratia angulata :
*panakenake

common pratia
creeping pratia
creeping-pratia

Pratia arenaria :
big-fruited pratia

Pseudopanax chathamicum :
hoho (prob. houhou)

*Chatham lancewood

Pseudopanax crassifolium :
hohoeka
*horoeka
koeka
kokoeka

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[1] Name not now recognised; included in *P. diversifolium.*
[2] Now includes also *P. Billardieri.*
[3] Name not now recognized; included in *P. vestitum.*
[4] Name not now recognised; included in *P. Richardi.*
[5] Name not now recognised; included in *P. Richardi.*
[6] Now includes also *P. aristatum* and *P. oculatum.*
[7] Now includes also *P. aculeatum.*

Pseudopanax crassifolium—cont.
ohoeka
tara-a-Maui (= trifoliate variety)

fish-bone tree
grass tree
grass-tree
ivy tree
lance-wood
*lancewood
thick-leaved lancewood
umbrella tree

Pseudopanax discolor :
bronze panax

Pseudopanax ferox :
savage lancewood
*toothed lancewood
toothed-leaved lancewood

Pseudopanax Lessonii :
houmapara
*houpara
houparapara
oho
parapara
whauwhau

northern lancewood
shore panax

Pseudopanax lineare :
mountain lancewood
true lancewood

Pteridium esculentum (Pteris aquilina var. esculenta) :
aruhe (= the rhizome)
kakaka (= the stem)
koeata (= the young shoots)
komeke (= the rhizome prepared for eating)
mahunu (= the young shoots)
manehu
meke (= the rhizome)
mohani (= the rhizome)
moheke (= the rhizome)
monehu (= the young shoots)
motuhanga (= the rhizome)
pakakohi (= the rhizome)
parara (= the rhizome)
rahurahu
*rauaruhe
rarahu
rarauhe
renga (= the rhizome)
roi (= the rhizome)
takaka

Pteridium esculentum—cont.
bracken
bracken fern
*bracken-fern
brake
brown fern
common bracken
common English bracken
common fern
fern

Pteris comans :
scarce bracken

Pteris incisa. See *Histiopteris.*

Pteris macilenta :
thin bracken

Pteris scaberula. See *Paesia.*

Pteris tremula :
tarawera
turawera

scented fern
scented-fern
stinking fern
stinking-fern
*trembling bracken

Pterostylis Banksii :
*tutukiwi

Banks' pterostylis
common hooded orchid
hooded orchid
*(elfs-hood)

Pterostylis graminea :
grass-like hooded orchid
narrow-leaved hooded orchid

Quintinia acutifolia :
mountain-tawheowheo
*(mountain-lilac)

Quintinia serrata :
kumarahou
*tawhewheo

native lilac
New Zealand lilac
white birch
serrated quintinia
*(Maori lilac)

†*Radicula Nasturtium aquaticum (N. officinale)* :
kowhitiwhiti

water-cress

Radicula Nasturtium palustre :
*hanea
panapana
poniu

marsh cress
small-leafed cress

Radicula Nasturtium (Cardamine) stylosum :
*matangoa

Ranunculus :
crowfoot

Ranuculus acaulis :
*shore-buttercup

Ranunculus Buchanani :
cut-leaved alpine buttercup
white cut-leaved alpine buttercup

Ranunculus crithmifolius :
samphire-leaved ranunculus
*(shingle-slip buttercup)

Ranunculus Godleyanus :
Godley's buttercup
yellow alpine buttercup
yellow mountain lily
*(yellow mountain-lily)

Ranunculus gracilipes :
slender alpine buttercup

Ranunculus Haastii :
fleshy-leaved buttercup
Haast's ranunculus

Ranunculus hirtus :
kopukapuka
*maruru

common New Zealand buttercup

Ranunculus insignis :
*korikori

hairy alpine buttercup
mountain-buttercup

Ranunculus Kirkii :
Stewart Island buttercup
*(Stewart buttercup)

Ranunculus lappaceus ·
butter cup
buttercup

Ranunculus lobulatus :
New Zealand Kaikoura buttercup
*(Kaikoura buttercup)

Ranunculus Lyallii :
giant white buttercup
Lyall's ranunculus
mountain lily
*mountain-lily
Mount Cook lily
rockwood lily
shepherd's lily
water lily
white buttercup

Ranunculus macropus :
*raoriki

*swamp-buttercup

Ranunculus multiscapus :
grassland buttercup
*grassland-buttercup

Ranunculus nivicola :
*Egmont buttercup
Mount Egmont buttercup
golden-yellow Mount Egmont buttercup
mountain yellow buttercup

Ranunculus rivularis :
raoriki
waoriki

swamp-buttercup
*water-buttercup

Ranunculus sericophyllus :
silky alpine buttercup

Raoulia australis :
common raoulia
patch-plant
silvery raoulia

Raoulia bryoides :
small vegetable-sheep

Raoulia eximia .
common vegetable-sheep
extraordinary raoulia
vegetable sheep
vegetable-sheep

Raoulia glabra :
glabrous raoulia

Raoulia Goyeni :
Stewart Island vegetable-sheep

Raoulia grandiflora :
large-flowered raoulia

Raoulia Haastii :
green raoulia
Haast's raoulia

Raoulia lutescens :
native scabweed
scabweed

Raoulia mammillaris :
breasted raoulia
New Zealand pincushion
vegetable sheep

Raoulia rubra :
green vegetable-sheep

Raoulia subsericea :
turfy raoulia

Raoulia tenuicaulis :
tutahuna

mat-raoulia

Rapanea. See *Suttonia.*

Rhabdothamnus Solandri :
kaikaiatua
matata
*taurepo
waiuatua

native arbutilon
native bignonia
Solander's rhabdothamnus
*(Maori arbutilon)

Rhipogonum scandens :
akapirita
akapita
kakareao
kakarewao
*kareao
karewao
kekereao
kotau (= young shoot)
pirita
taiore

black vine
bush sarsaparilla
climbing lily
climbing rhipogonum
hartwhan
karewan
native sarsaparilla
supple jack
supple-jack
*supplejack
supple jack vine
yam-creeper

Rhopalostylis Cheesemanii :
Kermadec nikau

Rhopalostylis (Areca) sapida :
kaihuia
miko
muka
munga
*nikau

cabbage palm
cabbage tree
cabbage-tree
fern-palm
New Zealand palm
nika-palm
nikau palm
nikau-palm
palm
savory palm-tree

Rubus australis :
tarakeke
taramoa
*tataramoa
tataramoa-turuhunga

bramble
briar
bush lawyer
*bush-lawyer
bushlawyer
Captain Cook's ropes
lawyer
native bramble
New Zealand bramble
southern bramble
wait-a-bit
wild Irishman

Rubus cissoides :
bush-lawyer
ivy-like bramble
leafless lawyer
yellow-prickled lawyer
*(yellow-prickle)

Rubus parvus :
creeping-lawyer
small bramble

Rubus schmidelioides :
bush-lawyer
rose-leaved lawyer
schmidelia-like bramble
*swamp-lawyer

Rubus schmidelioides var. *coloratus :*
white-leaved lawyer

Rubus subpauperatus :
narrow-leaved lawyer

Rumex flexuosus :
*runa
New Zealand dock
tortuous dock
*(Maori dock)

Rumex neglectus :
sea-shore dock
*shore-dock

Ruppia maritima :
tassel pondweed
*(tassel-pondweed)

Salicornia australis :
Australian glasswort
glasswort
Indian salicornia
marsh-samphire
samphire
southern glasswort
*(austral glasswort)

Salsola australis :
southern salsola
*(austral saltwort)

Salsola Kali :
*prickly saltwort

Samolus repens :
*maakoako

Samolus repens var. *procumbens :*
New Zealand water-pimpernel
primrose
wild thyme
southern water-pimpernel
*(Maori water-pimpernel)

Samolus littoralis :
sea-side samolus

Schefflera digitata :
kohi
kotete
patate
*pate
patete

*five-finger
five fingers
native fig
New Zealand fig
pipewood
snotty gob
white wood

Schizaea australis :
dwarf comb fern
*(dwarf comb-fern)

Schizaea bifida :
forked comb fern
*(forked comb-fern)

Schizaea dichotoma :
broad comb fern
kauri fern
*(kauri-fern)

Schizaea fistulosa :
rush fern
*rush-fern
slender comb fern
slender comb-fern

Schoenus pauciflorus :
bog rush
false snow-grass

Scirpus americanus :
*three-square

Scirpus antarcticus :
antarctic club-rush

Scirpus aucklandicus :
Auckland Island club-rush

Scirpus cernuus :
drooping club-rush
nodding club-rush

Scirpus frondosus. See *Desmoschoenus spiralis.*

Scirpus inundatus :
swamp club-rush
water club-rush

Scirpus lacustris :
kapungawha
*kopupu
kopupungawha
kuwawa
papao
wawa

great bulrush

Scirpus maritimus :[1]
kukuraho
*ririwaka

club rush
purua-grass

Scirpus nodosus :
wiwi

common club-rush
stiff bulrush
stiff club-rush

Scirpus robustus :[2]
salt-marsh bulrush
*sea club-rush

Scirpus sulcatus Thouars var. *distigmatosa :*
proliferous club-rush

Scleranthus biflorus :
kohukohu
*naereere

common scleranth
cushion plant

Selliera radicans :
raumangu
rekoreko
*remuremu

creeping selliera
creeping-selliera
rooting selliera

Senecio :
alpine marigold
shrub-groundsel

Senecio Banksii :
East Cape groundsel

Senecio bellidioides :
common mountain-groundsel
common New Zealand groundsel
*(Maori groundsel)

Senecio Bidwillii :
Bidwell's shrubby groundsel

Senecio elaeagnifolius :
brown backs
common mountain shrubby groundsel
*(brown-backs)

Senecio Hectori :
deciduous tree-groundsel

Senecio Huntii :
*rautini

[1] Name not now recognised; included in *S. robustus.*
[2] Now includes also *S. maritimus.*

Senecio Kirkii :
kohurangi
kokohurangi
komingiroa
orooro
*tapairu

daisy shrub
forest-groundsel
forest tree-groundsel
Kirk's groundsel
shrubby forest-groundsel

Senecio latifolius :
puhaureroa
*puwhaureroa

Senecio lautus :
coast groundsel
coast-groundsel
elegant senecio
*shore-groundsel

Senecio Lyallii :
Lyall's groundsel
*white marigold

Senecio Monroi :
rock shrub-groundsel

Senecio perdicioides :
*raukumara
puarangitoto

shrubby groundsel

Senecio rotundifolius :
*puheretaiko
puwharetaiko

*leather-leaf
leathern leaf
mutton bird scrub
mutton-bird scrub
mutton-bird shrub
round-leaved shrubby groundsel

Senecio saxifragoides :
Port Hills groundsel
*yellow rock-daisy

Senecio sciadophilus :
climbing daisy
climbing-groundsel
mutton-bird scrub

Senecio scorzoneroides :
great white groundsel
mountain marguerite
*snow-groundsel

Senecio Stewartiae :
Stewart Island shrubby groundsel
Stewart Island tree-groundsel
*(Stewart tree-groundsel)

Sicyos angulatus. See *S. australis*, footnote.

Sicyos australis :[1]
mawhai

Australian gourd
climbing-gourd
southern sicyos
*(climbing gourd)

Sideroxylon costatum. See *S. novo-zealandicum*, footnote.

Sideroxylon novo-zelandicum :[2]
orewa
pou
*tawapou

New Zealand olive

Siegesbeckia aculeatum :
puniu

Siegesbeckia orientalis :
*punawaru

Siphonidium longiflorum :
slender-flowered eyebright

Solanum aviculare :
horeto (= ripe fruit)
kahoho (= the fruit)
kohoho
peoi
popopo
poporo
*poroporo
poroporotanguru

borra borra
bul-a-bul
bul-bul
bulli-bull
bulli bulli
bulli-bulli
bullibulli
bullybull
common solanum
cut-leaved nightshade
potato plant

Solanum aviculare var. *albiflora* :
white poroporo

Solanum nigrum :
poroporo-raupeti
*raupeti
remuroa

black nightshade
dwarf New Zealand nightshade
nightshade

†*Solanum tuberosum* :
*hiwai
kapana
maketau
parareka
parete
riwai
tiawa
Cultivated varieties—
hingongi
huamango
kotipo
papaka
pau
piho
raparaparuru
rape
rokeroke
ropi
taeaka
taewa
tatairongo
uwhi
waeruru

†*Sonchus asper* :
kautara
rauroroa
taweke
wekeweke

*sow-thistle

Sonchus grandifolius :
Chatham Island sow-thistle
great sow-thistle
great sowthistle

Sonchus littoralis :
coastal sow-thistle
coastal sowthistle
fleshy-leaved sow-thistle
rock sow-thistle

†*Sonchus oleraceus* :
pororua
puwha
*rauriki

sow-thistle

Sophora chathamica :
*Chatham kowhai

[1] Now includes also *S. angulatus*.
[2] Now includes also *S. costatum*.

Sophora grandiflora :
kowhai

large-flowered kowhai
New Zealand acacia
New Zealand laburnum

Sophora microphylla :
kowhai

common kowhai
goi
New Zealand laburnum
small-leaved kowhai
yellow olianthus

Sophora prostrata :
dwarf kowhai
prostrate kowhai

Sophora tetraptera[1]
(part = *Edwardsia*)

houma
*kowhai
kowhai-taepa (= drooping variety)
kowhai-tauiti (a variety)

ghoa
ghoai
goa
goai
gohi
goi
gowai
gowhai
kohai
kowai
kowhia
locust tree
locust-tree
native laburnum
native mimosa
New Zealand laburnum
yellow kowhai
yellow parrot's bill

Sparganium antipodum :
*maru

Sparganium subglobosum :
creeping New Zealand burr-reed
New Zealand burr-reed
simple bur-reed
*(Maori burr-reed)

Spergularia media :
salt-marsh sand-spurrey

Sphagnum :
*bog-moss
swamp moss
sphagnum moss

Spinifex hirsutus :
kowhangatara
*puarere
raumoa
turikakoa
wawatai

*rolling-grass
silvery sand-grass
spiny rolling grass
spiny rolling-grass

Stellaria decipiens var. *angustata* :
*Antipodes chickweed

Stellaria gracilenta :
New Zealand chickweed
*(Maori chickweed)

Stellaria media :
kohukohu

Stellaria parviflora :
small-flowered chickweed
stitchwort

Stellaria Roughii :
Rough's chickweed

Stilbocarpa Lyallii :
punui

Lyall's stilbocarpa
Stewart Island stilbocarpa

Stilbocarpa polaris :
puniu
punui

polar stilbocarpa
sacrie
*(Dundonald-herb)

Stipa arundinacea :
hunangamoho

New Zealand wind grass

Styphelia. See *Cyathodes*.

Suaeda maritima :
*sea-blite

Suttonia australis (*Rapanea* (*Myrsine*) *Urvillei*) :
*mapau
mapou
mataira
matipou
tapau
takapou
tipau

Suttonia australis—cont.
black mapou
D'Urville's rapanea
maple
mappo
red birch
red-birch
red mapau
red maple
red-maple
red matipo

Suttonia chathamica :
Chatham Island matipo
*(Chatham matipo)

Suttonia Coxii :
*swamp-matipo

Suttonia divaricata :
divaricate suttonia
*weeping matipo
weeping-matipo
wiry matipo

Suttonia (*Rapanea*) *montana* :
weeping tree

Suttonia nummularia .
*creeping matipo
creeping-matipo

Suttonia (*Rapanea*) *salicina* :
*toro

long leaf matipou
long-leaved matipo
willow-leaved rapanea

Taraxacum magellanicum :
New Zealand dandelion
*(Maori dandelion)

Tetragonia expansa :
kokihi
? panamata
? paraihia
*rengamutu
rengarenga
tutaeikamoana

native ice-plant
New Zealand spinach
spinach
summer spinach
*(Maori spinach)

[1] *Sophora tetraptera* should perhaps be divided into three species of *Edwardsia*, but is left here to save confusion. Dr. L. Cockayne puts the whole of *Sophora* into *Edwardsia*, but admits it is a matter of opinion.

Tetragonia trigyna :
kokihi

beach spinach
climbing New Zealand spinach
ice-plant
*(beach-spinach)

Tetrapathaea tetrandra (australis) (Passiflora tetrandra) :
aka
akakaiku
akakaikuku
akakaimanu
akakohia
akakuku[1]
kahia
kaimanu
kohe
*kohia
kupapa
pohuehue
popohue
powhiwhi

native passion-flower
native passion-vine
New Zealand passion-flower
New Zealand passionflower
orange berry
passion flower
passion-flower
tetrandrous passion-flower
*(Maori passion-flower)

Thelymitra longifolia :
*maikuku

common thelymitra
long-leaved thelymitra

Thelymitra pulchella :
*maikaika

Thelymitra uniflora :
blue thelymitra
*(blue maikuku)

Todea barbara :
hard todea
king fern

Todea superba. See *Leptopteris superba*.

Trichomanes :
bristle ferns

Trichomanes Colensoi :
Colenso's bristle fern

Trichomanes elongatum :
black bristle fern
bristle-fern
stiff bristle fern

Trichomanes humile :
drooping bristle fern
humble-fern

Trichomanes Lyallii :
Lyall's bristle fern
Lyall's bristle-fern

Trichomanes reniforme :
konehu
kopakopa
*raurenga

kidney fern
*kidney-fern
kidney-leaf bristle fern

Trichomanes strictum.
stiff bristle fern

Trichomanes venosum :
veined filmy-fern
veined bristle fern
veined bristle-fern

Triglochin striatum var. *filifolium* :
southern arrow-grass
*three-ribbed arrow-grass

Triglochin triandrum :
arrow grass

Triodia exigua :
few-flowered oat grass
*mountain-twitch

Trisetum antarcticum :
native oat grass
shining oat grass
shining oat-grass

Trisetum subspicatum :
spiked oat grass

Trisetum Youngii :
Young's oat-grass

Tupeia antarctica :
kohuorangi
pirinoa
*pirita
tapia

antarctic mistletoe
antarctic tupeia
*green mistletoe

Tyndaridea anomala :
kohuwai

Typha angustifolia :
hune (= feathery seeds)
karito
koare
koareare (= rhizome)
konehu-raupo (= pollen)
kopupungawha
koreirei (= rhizome)
korito (= young shoots)
kouka (= rhizome)
ngawha
pungapunga (= pollen)
*raupo

bulrush
bullrush
cat's tail
flag
large bulrush
marsh reed
reedmace
rushes (ra-poo)

Uncinia :
matau

*hooked sedge

Uncinia australis See *U. uncinata* :

Uncinia caespitosa :
narrow-leaved uncinia

Uncinia compacta :
mountain uncinia

Uncinia filiformis :
slender uncinia

Uncinia leptostachya :
matauriiriki

tall uncinia

Uncinia pedicellata :
Stewart Island uncinia
*(Stewart uncinia)

Uncinia rigida :
stiff uncinia

Uncinia riparia :
matauriiriki

leafy uncinia

Uncinia rubra :
red uncinia

Uncinia uncinata :[2]
*kamu
matau-a-Maui

broad-leaved uncinia

[1] Abbreviation of akakaikuku ("food-vine of the pigeon").
[2] Now includes also *U. australis*.

Urtica australis :
*taraonga
taraongaonga
subantarctic nettle
*(Antipodes nettle)

Urtica ferox :
*ongaonga
taraonga
taraongaonga
bush-nettle
fierce nettle
nettle
nettle tree
shrubby nettle
tree nettle
*tree-nettle
true nettle

Urtica incisa :
ongaonga
*dwarf nettle
forest-nettle
ground nettle
nettle

Usnea barbata ;
*angiangi

Utricularia monanthos :
bladder-wort
bladderwort
common bladder-wort
*(purple bladderwort)

Utricularia protrusa :
bladderwort
*(floating bladderwort)

Veronica. See *Hebe* for all except the three following.

Veronica catarractae :
waterfall veronica
*(waterfall-koromiko)

Veronica Hookeriana :
Hooker's veronica

Veronica spathulata :
*scoria-koromiko
snowy veronica

Viola Cunninghamii :
common New Zealand violet
Cunningham's violet
native violet
New Zealand violet
violet
*(Maori violet)

Viola filicaulis :
native violet
*slender violet
thread-like violet
violet

Viola filicaulis var. *hydrocotyloides* :
*water-penny violet

Viola Lyallii :
haka
white violet

Viscum Lindsayi :
Lindsay's mistletoe

Viscum salicornioides :
salicornia-like mistletoe

Vitex lucens :
kauere
*puriri
boradi
iron wood
New Zealand oak
New Zealand teak
puredi
puridi
teak

Vittadinia australis :
southern vittadinia

Wahlenbergia albomarginata :
blue bell
blue-bell
bluebell
native blue bell
New Zealand blue bell
New Zealand blue-bell
New Zealand bluebell
*(Maori bluebell)

Wahlenbergia cartilaginea :
*rock-bluebell

Wahlenbergia gracilis :
*rimuroa
bell-flower
blue bell
blue-bell
bluebell
graceful blue-bell
hare bell
native harebell
New Zealand bluebell
slender blue-bell
slender bluebell

Wahlenbergia Matthewsii :
bell-flower

Weinmannia racemosa :
*kamahi
tawhero
towai
black birch
brown birch
karmai
racemose weinmannia
red birch
red-birch
white birch

Weinmannia silvicola :
*tawhero
towai
forest-loving weinmannia

Wintera (Drimys) axillaris :
*horopito
matou (= the fruit)
puhikawa
axil-flowered drimys
Maori pain-killer
nutmeg tree
pepper tree
*pepper-tree
peppertree
pepper-wood

Wintera (Drimys) colorata :
*oramarama
ramarama
blotched-leaved pepper-tree
false native pepper
pepper tree
pepper-tree
red-blotched horopito
*red horopito

†*Zea Mays* :
kanga
kopakipaki
parate
maize

Zostera :
*sea-wrack

Zostera nana
*rimurehia
eel-grass
*grass-wrack
sea-grass

Zostera tasmanica :
*sea-grass

Determination of Word-rhythm.

By H. D. BROADHEAD, Litt.D., Canterbury College.

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IN my work on *Latin Prose Rhythm* I have endeavoured to establish (1) that words have an inherent rhythm, and (2) that in Latin this inherent rhythm is enforced by a stress accent. What I wish to do in this paper is to explain briefly the psychological foundations of my theory, and to support my general contention by particular illustrations taken from the classical languages.

It is necessary first to point out the hazy notion that generally exists as to what rhythm in language really is. Many suppose that rhythm is to be found chiefly, if not exclusively, in poetry; to speak of rhythm in prose seems to them absurd. Others admit the existence of prose-rhythm, but believe that when it occurs it approximates very closely to the regularly-recurrent rhythms of verse. Such misconceptions are widely prevalent, and show the need of a treatment that will get to the very roots of the matter. Far from believing that prose-rhythm can be understood in the light of verse technique, I am persuaded that the converse is true—the rhythms of verse can be properly understood only if we first grasp the rhythms of prose.

It will be convenient here to answer a question that the reader is doubtless asking: What exactly is the difference between rhythm and metre? Rhythm is an ordered succession of syllables grouped into units; but it is important to note that the grouping may be (*a*) natural, or (*b*) artificial. The natural grouping is found in normal prose utterance, and to a certain extent in verse; but frequently, especially in melic verse, the syllables are grouped in a way that would be impossible in natural speech. When this happens there is no distinction between the rhythm and the metre; for to read such passages as prose would be to destroy the rhythm intended by the poet. They must either be sung to music or be recited with "plasma." But there are cases in which the metrical unit is not always the same as the rhythmical unit—viz., when a certain sequence of long and short syllables is preserved along with the natural pronunciation of the words. This happens in the iambic trimeter. Two lines quantitatively identical may contain quite different rhythms. Rhythm is produced by the subjective process of grouping syllables; metre is the term for a purely objective description of syllabic groups that may or may not correspond to a live reality. If they do not correspond, the real units are those of natural speech, and the metrical feet are convenient simply to describe the minimum that lines, rhythmically different, have in common. It is the same with English. Take a "regular" line from Milton's or Shakespeare's blank verse—*i.e.*, one containing ten syllables. These the metrician divides into five "feet," which, provided the accent falls on the second syllable, are strangely termed "accentual iambi." But in very many

lines we find more syllables than ten and fewer accents than five, and, since rhythm in English verse depends largely on accent, this "metrical" description is often utterly inadequate for conveying any idea of the varied rhythms of different lines. Thus, in the line "Antonio, gratify this gentleman" ("Merchant of Venice," iv, 1, 400), there are only three accents, and its rhythm is quite different from that found in "we all expect a gentle answer, Jew" (*ibid.*, 34).

Again, if the accent falls on the first syllable of the so-called "foot"—*e.g.*, "Bring me the fairest creature northward born," the first (metrical) foot is not an "accentual iambus," but an "accentual trochee." In reality, the first rhythmical group is "Bring me the," and the whole line is in descending rhythm. It is time we gave up the futile system that has so long been in vogue, and recognized that rhythm cannot be conveyed by the artificial dissection of a line into so many "feet," that very often exist only for the eye. Such "paper rhythm" is divorced from reality. Rhythm, in prose and non-melic verse, is produced by the natural groupings of syllables as we hear them formed in ordinary speech.

Now, to confine our attention to the classical languages, most writers on the rhythms of classical verse and prose agree in believing that rhythm is simply a matter of long and short syllables. If we take a phrase the words of which are united into one rhythmical series, the only way (on this assumption) to describe the rhythm would be to write down the long and short syllables in order. To attempt to find "feet" on the basis of mere quantity is, as Laurand shows (*Études sur le Style de Cicéron*, p. 138), a hopeless task—you can find whatever "feet" you please. In verse the division by feet is easy, because the sequence of longs and shorts is pretty regular, or at least subject to well-defined variations. In prose, on the other hand, the feet are, in Cicero's words, "*quasi mixti et confusi.*" Laurand feels that the mixture and confusion is such that there emerges only the "*règle négative d'éviter les vers et les parties de vers.*" It is true that at the end of a sentence or phrase certain sequences are particularly common; but, even so, alternative scansions are possible.

This extraordinary view implies that words are really amorphous agglomerations of syllables, which make us sensible of a pervading rhythm, but refuse to be dissected or split up into groups. Can anything show more clearly how little the real nature of rhythm in language is generally understood? How can a mere succession of syllables of itself constitute rhythm? Professor Sirén says (*Essentials in Art*, p. 11): "Rhythm is essentially distinct from mere mechanical repetition. It indicates a rising or falling of certain *units*, and reveals thereby direction or intention. Rhythm may be even or uneven. In the former case the units follow one another at similar intervals; in the latter case the intervals are unequal."

An important point to recognize is that without units rhythm cannot exist; it is "artistically controlled movement," the "guiding principle in creation" (*op. cit.*, pp. 11, 14). "It is a universal law," writes Goodell (*Chapters on Greek Metric*, p. 65), "that man is a creature who rhythmizes . . . every kind of action that admits of it." So in speech "there must be a τάξις, an arrangement of times *inter se*" (*op. cit.*, p. 61). This arrangement or grouping is necessitated by the irresistible rhythmizing impulse in man. In the case of English and German it is clear that the rhythmical units are determined mainly by accent, though the syllables composing a unit may exhibit infinite variations of quantity. In the case of the classical languages, investigators have been mostly content with

counting up syllables, and have regarded the rhythm as objectively existent on the printed page, oblivious to the fact that it is only with the subjective process of grouping the syllables that rhythm can be said to emerge.

In any polysyllabic word there must be a grouping of the syllables; the word has an "inherent rhythm," for we surely cannot suppose that the same word is rhythmized now in one way, now in another.

Let me now summarize the psychological principles on which my theory is based :—

(1.) The rhythmizing impulse in man affects speech just as much as any physical movement; syllables cannot, even in the most artless speech, follow one another without being grouped in some way by the speaker.

(2.) This rhythmizing impulse causes us to group even mechanically produced sounds (*e.g.*, the ticking of a clock, the stroke of an engine, &c.), though the sounds are qualitatively identical and occupy precisely the same time and occur at equal intervals.

(3.) Where some difference in time or quality is introduced, the grouping is forced upon the percipient. The natural tendency to rhythmize is now assisted and enforced by objectively existent distinctions of time or quality: *e.g.*, if alternate taps are louder than the others, there will be a grouping by twos (or by fours, eights, &c., according to the rapidity of succession: in the case of such a larger group we are still conscious of the subordinate groups that compose it). Or, if the alternate taps are slightly longer in time, the same groupings will still be produced. (It is worth noting that psychological experiment has shown that a quantitative difference of a few thousandths of a second is sufficient to cause a grouping).

These are facts beyond dispute, and there is no reason to suppose that the tendency to rhythmize was different in the men of 2,400 years ago from what it is in the men of to-day. Two thousand years is but a fraction of the time covered by the evolution of mankind, and such rhythmical tendencies, though they now seem to be autonomous, are rooted in age-long physiological processes. It will follow that if we pronounce Latin and Greek words with due observance of quantity we should be able to rhythmize them in essentially the same way as did the ancients. This I believe to be the case, but I shall try to establish my thesis independently of this (no doubt debatable) conclusion.

(*a.*) Take a Latin word like *attribuitis*: the accent falls on the antepenult. Professor Sonnenschein believes that accent in Latin is a constitutive element in rhythm (*Year's Work in Classical Studies*, 1914, p. 63), and would agree that this word is to be rhythmized as trochee + tribrach (with a secondary accent on the first syllable). This means (1) that the speaker *mentally* groups the word into two units; (2) that this grouping is also made perceptible to the auditor, since a stress (according to 3 above) is an objective means of marking off one group from another. It will then be impossible to rhythmize *attribuitis* as dactyl + pyrrhic or as monosyllable + ˘ ˘ ˘ ˘, just as in the English word "ambiguity" the rhythmical units are fixed by the accents (of course, the stress in English words is much heavier than in Latin). But the correct rhythmization is objectively indicated not only by the accent, but also by the slight increase in the time given to the second syllable of *attribuitis*. Let any one read *attribu-* as a dactyl and he will soon be conscious of the difference in the time of the second syllable.

(*b.*) In the Greek word ἐσκορόδισας the rhythmical units are the same as in the Latin word *attribuitis*, only we do not know of any stress being placed

on the third syllable. In Greek, then, the variation of time alone makes perceptible to the auditor the correct grouping.

(*c.*) But, while it may be agreed that *attribuitis* is — ⏑ + ⏑ ⏑ ⏑, it may not be conceded that ἐσκορόδισας is to be treated in the same way. There are two possible lines of argument—(1) the psychological; (2) the evidential, which adduces certain facts to be obtained from a study of the literature or the criticism of the ancients.

(1.) A full treatment of the psychological considerations would demand more space than can here be devoted to them, but the case may be briefly outlined as follows:—

(*a.*) The groupings referred to in (2) above are generally by twos, less commonly by threes, or exact multiples of these.

(*b.*) The rate of utterance in ordinary speech is favourable to the groupings by twos or threes.

(*c.*) A word, therefore, like συλλήψεσθαι would naturally be rhythmized as two spondees. Even if we regard it as one rhythmical whole, we are still conscious of the two groups composing it (*cf.* the dipodies of the metrists). In fact, we may say that the word has an inherent rhythm (for which see *Latin Prose Rhythm*, chapter iii)—"inherent" because the rhythmizing impulse could deal with it satisfactorily in only one way. A word composed of six long syllables (*e.g.*, ἐξαλλαχθήσεσθαι) would be rhythmized as three spondees, because the rate of utterance is not great enough to allow of their being grouped in threes. On the other hand, a word like καταλαβόμενος would be rhythmized as two tribrachs, since the rate of utterance for each syllable has been practically doubled, thus enabling larger syllabic groups to be formed.

(*d.*) In the example just given the syllables are either all long or all short; when long and short syllables are intermingled, the correct grouping is still easier, if possible, to determine (see 3 above). Surely no one will argue that συλλαβέσθαι can be anything else than trochee + spondee, though the mere metrist would dissect it (in iambic verse) as long syllable + iambus + long syllable. So, ἡγεμονεύειν is dactyl + spondee; καταλαβέσθαι tribrach + spondee; Ἀθηναῖοι iambus + spondee; ἀναβήσεσθαι anapaest + spondee.

(*e.*) If a word, as a word, possesses an inherent rhythm, it must *end* with a rhythmical unit. It is inconceivable, for example, that συλλαβέσθαι was rhythmized in ordinary speech as cretic + long syllable. To rhythmize a word correctly we must first know how the syllables at the end are grouped—"*Respice finem.*" Thus we shall see that in many words the rhythmical unit (or units) is preceded by an anacrusis: *e.g.*, ἀπηλλάγησαν is anacrusis + two trochees, not, as the metrist would tell us, two iambi + short syllable. Τοξεύη is anacrusis + spondee. (See further below, 2 (*a*).)

(*f.*) So far we have been dealing with units containing three or four "morae"; there remains one other unit, the cretic, which contains five "morae," and no larger number can be rhythmized as a unit in one word. λαμβάνειν is a rhythmical unit, but συλλαμβάνειν is anacrusis + cretic. Similarly, ἡμετέρων is anacrusis + anapaest (the metrist calls it "choriambus," and regards it as one unit; this is possible only through πλάσμα—*e.g.*, when the word is sung to music). To rhythmize παρέρχεται as two iambi would be possible only on the assumption that the second syllable is slightly prolonged in time so as to make us conscious of such a division. In reality the antepenult is as closely attached to the penult as is the final syllable: for confirmation of this see below, 2 (*c*).

(*g.*) After what has been said I hope it will be evident that ἰσκορόδισας is to be rhythmized as trochee + tribrach. To pronounce it as though it were dactyl + pyrrhich would be possible only for βαρβαρόφωνοι, and would be as βάρβαρον to the Greek ear as *attribuitis* would sound to the Roman ear if the penult instead of the antepenult were accented. Two shorts cannot be rhythmized as a unit any more than a long syllable, to which they are equivalent in time, unless the two shorts compose one word, as πάτερ, where the two shorts are *not* equivalent in time to the short syllables of, say, an anapaest, because the final syllable of a word always has its time prolonged (*cf.* the *inane* of Quintilian). ἰσκορόδισας exhibits precisely the same rhythm as ἠλλάγησαν, the second long syllable being resolved. That the word was not anacrusis + ⏑ ⏑ ⏑ ⏑ will be proved by what follows below, 2 (*b*).

(2.) These psychological considerations have in themselves a high degree of antecedent probability, which develops into certainty when taken in connection with the following facts obtained from a study of the Greek iambic trimeter of tragedy, and of an instructive passage of Quintilian, with which it is convenient to begin.

(*a.*) Quintilian's attempts at prose-scansion show that he had not got past the metrical point of view, though his common-sense and sensitive ear sometimes assert themselves against the imperfectly conceived metrical principles that were current in his day. Thus he was not consulting his ears when he thought that *Brute dubitavi* might be dactyl + bacchius. But on one occasion at least, his evidence is of capital value. He tells us (ix, 4, 64) that *archipiratae*, πολλὰ τοξεύη, and *criminis causa* all exhibit the same rhythm, the chief difference being that the first was *molle*, the last *forte*. There can be no doubt, then, that πολλὰ τοξεύη was rhythmized as cretic + spondee, though, if the words occurred in trochaic metre, the metrist would find – ⏑ + – – + –. So we are bound to conclude that τοξεύη in prose utterance was rhythmized as anacrusis + spondee. (For further discussion see *op. cit.*, p. 44 *ff.*)

(*b.*) In the iambic trimeter of Greek tragedy a word like ἰσκορόδισας* is never found in such a position in the line that the second and third syllables together are the equivalent of the usual long syllable, while such a word *is* found at another part of the line where the two shorts regarded as replacing the long syllable are the third and fourth syllables. Thus in the line

σύ μ' ἰσκορόδισας, οὐκ ἐγὼ σ' ἰσκορόδισα

σύ μ' ἰσκορόδισας is correct, but ἰσκορόδισα is not allowed. To my mind this remarkable limitation proves conclusively that ἰσκορόδισα could not be rhythmized as anacrusis + ⏑ ⏑ ⏑ ⏑, and that the third and fourth syllables did cohere, so that the word ends with a tribrach. Now, as the tribrach is really a resolved trochee, the line above given ends with the equivalent of a double trochee. *Quid quaeris?*

(*c.*) The observance of Porson's law bears out my general contention that words have an inherent rhythm. Why should ὦναξ Ἡρακλεῖς be avoided in tragedy? Surely because the last word was felt to be a unit standing by itself ("law of the final cretic"), and the separation of spondee and cretic has a harsh effect, especially with a trochee preceding.

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* I do not take account of the first "foot," in which all sorts of licences are allowed. It is, as Christ says, "ein ausnahmsfass," on a totally different footing from the others.

ἐξορμωμένων and *ὦναξ Ἡρακλεῖς* exhibit the same rhythm (spondee + cretic), but the former is *molle* owing to the feet being comprised in one word, while the latter is *durum* (cf. *archipiratae* and *criminis causa*).

The whole trouble has arisen because students of rhythm have often failed to distinguish clearly between metre and rhythm. They have been accustomed for centuries to dissect a line according to its metrical feet, and have regarded these feet as representing the ultimate rhythmical fact. The metrical foot (I am speaking of non-melic verse) is an inert and dead entity that owes its existence solely to the *excogitation* of the metrician. It corresponds to no live reality. It may, properly understood, serve as a convenient means of describing what is common to a large number of lines, just as we may say of many of Shakespeare's lines that they contain ten syllables, and yet exhibit a great variety or rhythms owing to the fact that the accent does not always fall at the same place in the line. Metre simply tells us that a line is composed of so-many long and short syllables arranged in a more or less definite order, and conveys nothing of the wonderful variety of rhythms found in lines that have the same quantitative sequence. This variety is produced by the words, in which lie embedded the manifold rhythms that are woven into the metrical pattern. Take a line like

Καὶ πολλὰ μισηθεῖσα τῇδε γῇ πάρει.

Here the metrician sees — — | ⏑ — | — — | ⏑ — | ⏑ — | ⏑ ⏓, and he sees correctly, as far as his *sight* goes; the long and short syllables are there and are heard, but we are not conscious of the grouping he has made. The rhythm of the line—*i.e.*, the various units into which the syllables were grouped when uttered—is ⏓ | — ⏑ | — — | — ⏑ | — ⏑ ⏓ | ⏑ —, where the first syllable is an anacrusis. Of course, by no means every line begins with an anacrusis: *e.g.*,—

πάντων ὅσ' ἔστι κτημάτων ὑπέρτατον

shows the same sequence of long and short syllables, but there is no anacrusis, while the rhythmical units, with one exception, are quite different.

The pure iambic line consists of twelve syllables which are alternately short and long; we could be conscious of six "iambic" groups only if the syllables were uttered with a mechanically precise observance of the time, as if they were so many taps. But words are entities as well as syllables, and the individuality of a word is shown by a slight prolongation of the time of the final syllable; otherwise words in combination would be a confused medley of syllables. This principle it is that prevents the line being a mere singsong—

La-lah/la-lah/la-lah/&c.

The quantities are not grouped in any such lifeless and mechanical manner; they are the constants, but the groupings are the variables. *ἠλλάγησαν* strikes the ear as two trochees; —*αγη*— is only a grouping formed on paper—it did not strike the ear as an iambus; a true iambus is seen (i) in iambic words—*e.g.*, *πόλει*; (ii) in words compounded of two or more units—*e.g.*, *Ἀθηναῖοι*, *διαφθείρεται* (cf. *oportebat*, &c., in Latin). In *Ἀθηναῖοι* the time of —*η*— is slightly prolonged, so that it is not joined rhythmically to —*αῖ*— to form one unit, as it is in *Ἀθηναίοισιν*. The ear cannot fail to perceive the different grouping.

In Latin hexameter verse the quantitative and accentual principles are blended, because the accent was not sufficiently strong to prevent the

speaker giving the long and short syllables their full time (in English the strong accent obscures the quantities to a large extent—*i.e.*, it prevents our being able to divide syllables into two simple classes, in which the time-ratios are as near as possible 2/1 ; hence the futility of trying to write "quantitative" hexameters in English verse). But in the line

Italiam fato profugus Lavinaque venit

the accents are all heard, and the grouping of syllables is not

but — | ⏑ ⏑ — | — — | ⏑ ⏑ — — | — ⏑ ⏑ | — ⏓

We call it dactylic verse ; but this description simply applies to the succession of long and short syllables ; it does not give any indication of the rhythms—*i.e.*, the groupings of syllables as they struck the ear. *Itali-* is not a true dactyl as it was pronounced, because the stress accent on the second syllable absolutely forbids such a grouping ; the word is really — + anapaest. The first syllable is not joined to the two succeeding syllables to form a unit recognized by the ear, as is the case with the first syllable of the dactyl in the fifth foot ; in this line *-vinaque* is the only true dactyl. To pronounce *Itali-* as a true dactyl is to employ πλάσμα and to omit the accent, both quite unwarrantable proceedings.

NOTE ON ACCENT AND ΠΛΑΣΜΑ.

(1.) If the Latin was purely a pitch accent the grouping of syllables described above would be the same, but the accent would have nothing to do with making the correct groupings perceptible to the ear (*cf.* Greek) ; slight variations in time alone would suffice, as has been explained above for the rhythmization of Greek words.

(2.) Πλάσμα must be employed if we wish to convey, by reading a line, the rhythms that would be made clear if the words were sung to music ; otherwise we should altogether miss the rhythms of the Greek choruses. The music does not care how the syllables are ordinarily grouped in prose utterance ; it makes its own groupings, to which the singer must conform, though the *time* of the music is to a large extent determined by the quantities of the syllables.

Effects of changing Price-levels on the Economic Development of New Zealand.

By J. B. Condliffe, Professor of Economics, Canterbury College.

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In the following paper an attempt has been made to measure the influence of the secular changes in the price-level upon the economic development of New Zealand as it is reflected in the statistics of imports and exports, and in the relation between them which is generally known as the "balance of trade." Some general aspects of the questions here dealt with may be found in an article by the writer contributed to the *Accountants' Journal.** It is the purpose of this paper to discuss the adequacy of the statistical methods used to obtain the general conclusions arrived at in that article.

1. The Balance of Trade as an Index of Prosperity and Development.

Statistics of external trade are in themselves not an adequate test of national prosperity or progress, but in a country like New Zealand, which is so small that it must depend more than well-established and older lands upon the exchange of products with other countries, the importance of the trade statistics is proportionately great.

There is no index of annual production available in New Zealand similar to that provided by the Commonwealth Statistician for Australia,† and in the absence of such data it is not possible to say accurately what is the relative importance of the exporting industries as compared with the domestic production and consumption of the Dominion. But what statistics are available, such as the occupations disclosed by the census returns, indicate that the overwhelming majority of the population of the Dominion is occupied either directly in the primary industries or in occupations directly dependent upon those primary industries. The main industries are—Agricultural and pastoral, employing 132,000 workers; forestry, 10,000; fishing and trapping, 2,000; mining, 8,000—a total of at least 150,000 workers directly engaged in the primary extractive industries.‡

The census of industrial production shows that in all the factories of the Dominion the employees totalled 70,316, a large proportion of these being engaged in what have been described as the "semi-primary" industries, such as meat-freezing works and dairy factories.§ In many of these industries also it will be admitted, if only from the events of the past crisis, that prosperity is dependent obviously and directly upon the output and prices of our primary exports.

The proportion of domestic production in comparison with exports is, however, growing steadily, as may be seen from the fact that between 1896 and 1922 the population of the Dominion grew in the proportion of 100 : 180, while the number of persons included in the secondary industries (including the semi-primary) increased in the proportion of 100 : 223.||

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* *Accountants' Journal,* November and December, 1924; January, 1925.

† *Commonwealth Year-book; also Pocket Compendium of Australian Statistics,* 1924, p. 50.

‡ *New Zealand Official Year-book,* 1924, p. 749.

§ *Ibid,* Section XX.

|| Calculated from official statistics—*Year-books,* 1897 and 1924.

There is a similar development in the proportions of the population engaged in commercial and professional services. A certain proportion of the primary production (a proportion which is increasing) is directed also to the local market. This is particularly so in Canterbury with wheat and potatoes. Indeed, statistics show that Canterbury imports more than it exports overseas, and obtains the balance of its purchasing-power by supplying the rest of New Zealand with foodstuffs and manufactures.

All these factors, however, while they render caution necessary in the use of statistics of foreign trade as an indication of progress in the Dominion, do not invalidate the use of such an index, for the following reasons :—

(*a*.) The statistics of occupation show that the primary exporting industries still engage the largest proportion of the workers.

(*b*.) Of the industries and occupations which are not directly concerned with exporting, a very large but not exactly measurable proportion depend directly and almost completely upon the purchasing-power made available by the exports.

(*c*.) Research undertaken by Mr. A. H. Tocker, M.A., of Canterbury College, has shown conclusively that the policy of the banks in controlling credit advances in New Zealand for all industries varies in the closest possible manner with the balance of trade, which builds up a fund of purchasing-power in London upon which the banks work as through a "credit-exchange" standard.*

For all industries and occupations, therefore, the credit policy upon which expansion or contraction largely depends is regulated by the balance of trade, which is taken in this paper as an indication of the economic health of the Dominion.

2. THE CALCULATION OF AN INDEX OF PRODUCTIVITY FROM THE EXPORT RETURNS.

The total figures of imports and exports by themselves do not convey any clear impression, except perhaps to expert eyes, of the changes in economic conditions which they record. The accuracy of these official figures, not perhaps in details but certainly in totals, the writer knows from experience in the Departments of Customs and Statistics to be very high.† The variety and nature of the Customs tariff make the production of original invoices indispensable, and the total values, as distinct from the values of particular items, must be accurate within a negligible percentage. There is less accuracy in the figures officially given for the values of exports, which, in some important cases, must be estimated here before being sold in London. But in this case, fortunately, the nature of the exports is such that the quantities exported are easily and accurately obtained. The official statistics have therefore been accepted as the basis of calculation.

There is, however, some difficulty in interpretation, even when the trade statistics are compared with the corresponding figures of population, and the chief impression gained is one of constant and unvarying progress (see Diagram A). There are two main confusing factors which must be eliminated before the essential facts can be made clear—viz., the

* "Monetary Standards in Australia and New Zealand," *Economic Journal*, December, 1924.

† The chief defect of the import statistics is a consistent tendency to under-valuation because of the practice of adding only 10 per cent. to invoice values of *ad valorem* goods in order to arrive at landed value; probably 20 per cent. would be nearer the mark. But this under-valuation does not destroy the validity of the following argument, since it is consistent from year to year; it does, however, make the balance of exports over imports appear more favourable than it really is. (*N.Z. Official Year-book*, 1925, p. 272; also League of Nations' *Memo. on Balance of Trade Payments*, 1910–23, p. 272, footnote.)

continuously increasing population over the whole period covered, and the changing trend of the level of general prices. Both of these factors have been eliminated by the following method :—

(*a.*) The total values of imports and exports were divided by the mean population for each year. This gave the *per capita* values of imports and exports. As a result the contrast between the period 1873–95, when prices were falling, and the subsequent period 1895–1920, when prices were rising, is strongly marked.*

(*b.*) This contrast is, however, accentuated by the very fact of the changing price-levels; and in order to discover how far the falling tendency of the *per capita* trade per head in the period 1873–95, and the rising tendency in the period 1895–1920, were due merely to falling or rising prices it is necessary to eliminate the influence of the changing price-levels. By this means it should be possible to get an estimate of the actual quantities of imports and exports per head of population as distinct from their values.

The only readily available means of making the necessary correction is by the use of index numbers of general wholesale prices. For the purpose of this calculation the index numbers devised by Dr. McIlraith and the Government Statistician have been divided into the value of trade per head for each year, and the results are plotted on Diagram B as shown.

3. The Validity of the Use of Index Numbers as a Measure of Price-changes.

It is not proposed to make an elaborate justification of the method of index numbers in general. In practically every country in recent years index numbers of general prices have been devised to measure changes in the value of money. In effect they take samples of important wholesale prices and combine these in a weighted average so as to produce an index which is typical, not of any particular price-change, but of the general movement. In other words, they measure the changes in the value of the currency unit as compared with goods in general. The general accuracy of these index numbers is unquestioned, though their use for particular purposes, such as the measurement of the cost of living or of changes in the prices of particular commodities, is not always satisfactory.

For the purpose of correcting the trade figures for changes in the value of currency, the index numbers of wholesale prices worked out in New Zealand by Dr. McIlraith for the period 1861–1910,† and by the Government Statistician for the period 1891–1923, were used.‡ These two index numbers were based upon different sets of commodities, calculated and weighted in different ways, and based upon different periods. Fortunately, the series overlap for the twenty years 1891–1910, and it was therefore possible in those years to compare the results arrived at by the use of each index number. It was intended to plot the results obtained in this period side by side in Diagram B, but the two lines ran so closely together that the effect on the diagram was confusing, and when a coefficient of correlation was calculated by the method of Pearson, based upon the formula $r = \frac{\Sigma(xy)}{n\sigma_1\sigma_2}$,§ the result was plus 0·99, or almost perfect correlation. This

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* See diagram, *New Zealand Official Year-book*, 1924, p. 253.

† McIlraith, *The Course of Prices in New Zealand.* Government Printer, 1912.

‡ *New Zealand Official Year-book*, 1924, pp. 646–48.

§ Where x and y are the deviations from the arithmetic mean of the two series, n is the number of items and σ_1 σ_2 the standard deviations of the two series.

in itself is proof that the method of index numbers does measure accurately the changes in the value of money, and establishes the validity of the method used to eliminate the fluctuations of the money-standard.

Further corroboration of the validity of this method is obtained for a later period, 1900–19, for which the Government Statistician has calculated, with full and accurate data derived from the actual quantities of 99 per cent. of the exports, an index of the true volume of exports from year to year.* When this index, calculated from actual quantities, is compared with the index obtained by using index numbers of wholesale prices in the method shown above, the coefficient of correlation obtained is plus 0·77.

The possible sources of divergence between the series are—(*a*) the necessity of accepting estimated export values; (*b*) the possible divergence of the prices of exported commodities from the general average level of prices (this is shown below to be important in later years); (*c*) different methods of calculation, especially different base periods. The high coefficient of correlation obtained is therefore satisfactory evidence of the validity of the method used.

4. The Trend shown by a Triennial Moving Average.

In order not to place too great reliance upon the figures in any particular year it was thought advisable to concentrate attention rather upon the general trend of the series than upon the annual variations from the trend. In order to do this a triennial moving average was calculated from the indices obtained in the manner described above, and it is this triennial moving average which is plotted in the heavier lines of Diagram B, while the lighter, broken lines show the annual figures.

When this moving average was calculated, a further comparison with a similar average calculated from the Government Statistician's index of export productivity disclosed the fact that the tendency towards greater productivity per head during the period 1895–1910, which is clearly marked in the writer's calculations, was not paralleled by the Government Statistician's index for the years since 1900, although the annual variations, as noted above, show such a high degree of correlation. Examination of the data shows that the discrepancy is to be found in the second of the two causes noted in paragraph 3—viz., the possible divergence of the prices of exported commodities from the general level. During the period of rising prices New Zealand not only had the advantage of her receipts from exports rising in advance of her costs, especially interest and wages, but a further advantage in the fact that the prices of her exports were rising faster than the general level of prices. This appears to be due, firstly, to the fact that wholesale produce dealt with in large-scale speculative markets responds more quickly to changes in the value of money than the more sluggish retail prices, and, secondly, to the fact that there has been an increasing world shortage of animal products such as comprise the bulk of our exports.

The application of this consideration to the index of import quantities is, of course, the reverse of its application to the exports. Attention has been drawn repeatedly to the narrowing of the margin between exports and imports in recent years, despite the fact that an increasing volume of payment abroad on behalf of a growing public debt should have had the effect of widening the margin. The narrowing shown in the diagram should, by reason of the fact noted above, be even more pronounced than it is,

* *New Zealand Official Year-book*, 1924, p. 284.

and this emphasizes the extent to which fresh borrowings were being undertaken both before the war and after, as well as during the actual war period.*

5. The Economic Bases of Pre-war Prosperity.

The economic bases of pre-war prosperity may perhaps best be considered in contrast with the conditions which were responsible for the depression of the preceding period.

It will be noted that during the period of the first Vogel borrowings, from 1870 to 1879, there is clear evidence of excessive importations based upon borrowed money. These importations come in successive peaks, each getting lower and lower. The continued excess of imports over exports in these years represents the loans which were brought in to develop the country. The continued depression in the quantity of imports per head of population after the slump of 1879 is evidence of the severe curtailment of purchasing-power in the worst years of the depression. Between the peak of 1878 and the trough of 1889 the volume of imports per head fell by 40 per cent., which represents a serious decline in the standard of living as well as a drastic economy in governmental expenditure upon constructional goods.

There is no evidence that this decline in importation was offset by any great development of local production. The secondary industries of New Zealand were then in the first stages of their development, and were themselves suffering heavily from foreign competition, as they must always do in the time of falling prices.

More significant is the decline in the exports per head during the period of the boom. The sharp decline in the first year or two of the period is mainly due to the falling-off in the production of alluvial gold. The persistent decline for the years following is more serious, representing as it does diminished productivity following a speculative boom launched at the beginning of a period of falling prices.

After the commercial development of refrigeration the increase in exporting-power is very rapid and great, amounting approximately to 40 per cent. in the same period. This is an indication of the cost to the colony of the borrowing policy, since the firstfruits of such an important development as refrigeration had to be sacrificed and supplemented by the rigid public and private economy indicated by the import returns. The last check to development offered by the banking crisis of the early "nineties" is also clearly seen.

By contrast with this period, the rapid expansion of exports and the consequent expansion of imports deserve examination. It is suggested that the chief economic bases of prosperity in this period, as indicated by the statistics used above, were—

(*a.*) A genuine increase in productivity per head of the population, somewhat exaggerated by the index shown in Diagram B, as was proved by comparison with the Government Statistician's figures. This increase is due to many causes, such as better farming methods, better commercial organization, the use of machinery. The chief feature of this increase has been the change to dairying, involving more intensive methods, co-operative factory production, machines, and closer settlement.

* The consistent under-valuation of imports noted above still further masks the narrowness of this margin. If allowance is made for the full landed value of imports and for the heavier interest payments abroad, there has been for many years past an actual excess of imports, balanced by increasing amounts of new loans. In 1923 these new loans amounted to £10,552,000 (*N.Z. Official Year-book*, 1925, p. 272). *Cf.* also a detailed calculation of the New Zealand balance of trade by Mr. A. H. Tocker in the *Lyttelton Times*, 19th August, 1925.

(*b.*) This extra productivity has been enhanced by constantly rising prices. The farmer was winning a greater produce from the soil, and getting for that produce higher and higher prices each year, while his main costs, especially interest and wages, lagged behind produce prices.

(*c.*) A relative shortage of animals and animal-products, due mainly to the rapid filling-up of North America, placed the exporters of animal-products in a still more favourable position.* This is quite consistent with a cyclical movement of trade, which seems to be clearly indicated in the trade returns, and has been noted by many different investigators, but never worked out in detail.†

6. The Spread of Prices in Recent Years.

While index numbers of wholesale prices are recognized as efficient instruments for measuring changes in the value of money as compared with goods in general, their efficiency for particular purposes is not so clear. The recent disputes in New Zealand over the adequacy of the Government Statistician's index number of retail prices as a measure of changes in the cost of living, while generally based upon wrong conceptions of the purposes and methods of index numbers, have proved the difficulty of devising an accurate index number of retail prices as a basis for wage calculations.

Wholesale prices, as a measure of monetary fluctuations, are not open to the same criticism; but, as has been indicated above, particular groups of commodities may diverge from the general movement because of special causes peculiar to those commodities. As monetary inflation raises the general level of prices sharply, this tendency to dispersion or spread of particular prices about the average is greatly increased, and is indeed one of the chief symptoms of the economic dislocation which always accompanies price-inflation.‡

An important example of this tendency is shown in the index number of wholesale prices calculated for New Zealand by the Government Statistician, and is summarized by Table 4 given below.

The tendency for prices to spread as inflation proceeded in the post-war boom is very noticeable when these series are plotted on a graph, and more noticeable still is the fact that the important pastoral products have risen less and fallen to lower levels since the slump than the merchandise we can import. This divergence is not the least of the handicaps under which the primary producer of the Dominion is suffering to-day. The extent to which the prices of products like building-materials and coal have soared away from export values may be taken also as one indication of the extent to which artificial interferences, such as protective tariffs, Government subsidies and advances, commercial combinations and industrial strife, have kept the level of domestic prices in New Zealand above the level of those products which have to face competitive world markets. This increased spread of the price-level has affected the calculation of export productivity considerably in the past few years.

By using the higher index number of general prices to correct the values of export products the quantity exported has been made to appear unduly

* *Cf.* SHANAHAN, *Animal Foodstuffs;* also periodical bulletins on "Stocks of Raw Materials," issued by London-Cambridge Economic Service.

† *E.g.*, COPLAND, *Wheat Production in New Zealand*, pp. 115–16. *Cf.* similar cycles worked out for the United States of America by Warren and Pearson, *The Agricultural Situation* (1924).

‡ *Cf. Statistical Journal*, March, 1924, "The Inter-relation and Distribution of Prices and their Incidence upon Price Stabilization," article by Norman Crump (editor, *Financial Times*).

low. There was during the war and the years immediately following the war a decided and indisputable tendency towards lowered productivity, which was masked by higher levels of prices; but since the slump productivity has increased again. This is due partly to the impetus given to dairying in the past few years, but mainly it is due to the heroic response of the small farmers of the Dominion to conditions of financial adversity.

TABLE 1.—ANNUAL IMPORTS AND EXPORTS OF NEW ZEALAND, 1853–1923, COMPARED WITH GROWTH OF POPULATION.

(Statistics taken from official publications.)

Year.	Imports. £00,000 omitted.	Exports. £00,000 omitted.	Population. 0,000 omitted.	Year.	Imports. £00,000 omitted.	Exports. £00,000 omitted.	Population. 0,000 omitted.
1853 ..	6	3	3	1889 ..	63	93	62
1854 ..	9	3	3	1890 ..	63	98	63
1855 ..	8	4	4	1891 ..	65	96	63
1856 ..	7	3	5	1892 ..	69	95	65
1857 ..	10	4	5	1893 ..	69	90	67
1858 ..	11	5	6	1894 ..	68	92	69
1859 ..	16	6	7	1895 ..	64	86	70
1860 ..	15	6	8	1896 ..	71	93	71
1861 ..	25	14	10	1897 ..	81	100	73
1862 ..	46	24	13	1898 ..	82	105	74
1863 ..	70	35	17	1899 ..	87	119	76
1864 ..	70	34	17	1900 ..	106	132	77
1865 ..	56	37	19	1901 ..	118	129	79
1866 ..	59	45	20	1902 ..	113	136	81
1867 ..	53	46	22	1903 ..	128	150	83
1868 ..	50	44	23	1904 ..	133	147	86
1869 ..	50	42	24	1905 ..	128	157	88
1870 ..	46	48	25	1906 ..	152	181	91
1871 ..	41	53	27	1907 ..	173	201	93
1872 ..	51	52	28	1908 ..	175	163	96
1873 ..	65	56	30	1909 ..	157	197	98
1874 ..	81	53	34	1910 ..	171	222	100
1875 ..	80	58	38	1911 ..	195	190	103
1876 ..	69	57	40	1912 ..	210	218	105
1877 ..	70	63	41	1913 ..	223	230	108
1878 ..	88	60	43	1914 ..	219	263	110
1879 ..	84	57	46	1915 ..	217	317	110
1880 ..	62	64	48	1916 ..	263	333	110
1881 ..	75	61	50	1917 ..	209	316	110
1882 ..	86	67	52	1918 ..	242	285	111
1883 ..	80	71	54	1919 ..	307	540	112
1884 ..	77	71	56	1920 ..	616	464	121
1885 ..	75	68	58	1921 ..	429	448	124
1886 ..	68	67	59	1922 ..	350	427	127
1887 ..	62	69	60	1923 ..	435	460	129
1888 ..	59	78	61				

TABLE 2.—VOLUME OF NEW ZEALAND IMPORTS AND EXPORTS PER HEAD OF POPULATION, 1861–1923.

Column 2 Total values of imports divided by mean population for the year.

Column 3 McIlraith's index, 1861–90; Government Statistician's ind x, 1891–1923.

Column 4 Annual index obtained by dividing column 3 into column 2. Three-year moving average to smooth annual fluctuations and disclose general trend.

Column 5 Total values of exports divided by mean population for the year.

Column 6 Identical with column 2.

Column 7 Annual index obtained by dividing column 6 into column 5. Three-year moving average to smooth annual fluctuations and disclose general trend.

1	2	3	4		5	6	7	
Year.	Imports *per Capita*.	Index of Whole-sale Prices.	Volume of Imports per Head. Annual Index.	Volume of Imports per Head. Three-year Moving Average.	Exports *per Capita*.	Index of Whole-sale Prices.	Volume of Exports per Head. Annual Index.	Volume of Exports per Head. Three-year Moving Average.
1861 ..	2·50	184	136	..	1·40	184	71	..
1862 ..	3·54	186	190	180	1·85	186	100	93
1863 ..	4·12	193	214	205	2·06	193	107	103
1864 ..	4·12	195	211	194	2·00	195	103	104
1865 ..	2·95	189	156	172	1·95	189	103	106
1866 ..	2·95	200	148	144	2·25	200	112	109
1867 ..	2·41	187	129	132	2·09	187	112	109
1868 ..	2·17	184	118	125	1·91	184	104	108
1869 ..	2·08	164	127	122	1·75	164	107	112
1870 ..	1·84	154	120	116	1·92	154	125	121
1871 ..	1·52	150	101	113	1·96	150	131	125
1872 ..	1·82	154	118	117	1·85	154	120	121
1873 ..	2·17	164	132	133	1·86	164	113	110
1874 ..	2·39	161	148	141	1·56	161	97	104
1875 ..	2·11	148	144	138	1·53	148	103	100
1876 ..	1·72	140	123	129	1·42	140	101	104
1877 ..	1·71	144	119	131	1·54	144	107	104
1878 ..	2·05	135	152	138	1·40	135	104	103
1879 ..	1·83	127	144	132	1·24	127	98	101
1880 ..	1·29	130	100	121	1·33	130	102	99
1881 ..	1·50	125	120	118	1·22	125	97	102
1882 ..	1·65	122	135	127	1·29	122	106	105
1883 ..	1·48	118	125	127	1·31	118	111	109
1884 ..	1·38	115	120	120	1·27	115	110	109
1885 ..	1·29	111	116	114	1·17	111	105	107
1886 ..	1·15	108	106	107	1·14	108	106	108
1887 ..	1·03	103	100	100	1·15	103	112	117
1888 ..	0·97	103	94	95	1·28	103	124	124
1889 ..	1·01	111	91	93	1·50	111	135	135
1890 ..	1·00	107	93	96	1·55	107	145	144

Table 2.—Volume of New Zealand Imports and Exports per Head of Population, 1861–1923—*continued*.

1	2	3	4		5	6	7	
Year.	Imports *per Capita*.	Index of Whole-sale Prices.	Volume of Imports per Head.		Exports *per Capita*.	Index of Whole-sale Prices.	Volume of Exports per Head.	
			Annual Index.	Three-year Moving Average.			Annual Index.	Three-year Moving Average.
1891 ..	1·03	99	104	102	1·52	99	153	149
1892 ..	1·07	97	110	107	1·46	97	150	147
1893 ..	1·03	97	106	107	1·34	97	138	144
1894 ..	0·99	93	106	104	1·33	93	144	139
1895 ..	0·91	92	99	104	1·23	92	134	139
1896 ..	1·00	94	106	108	1·31	94	139	140
1897 ..	1·11	94	118	113	1·37	94	146	144
1898 ..	1·11	97	114	120	1·42	97	146	156
1899 ..	1·15	89	129	131	1·56	89	175	169
1900 ..	1·38	92	150	146	1·71	92	186	179
1901 ..	1·49	93	160	151	1·63	93	175	178
1902 ..	1·40	97	144	155	1·68	97	173	180
1903 ..	1·54	95	162	158	1·81	95	191	183
1904 ..	1·55	92	168	159	1·71	92	186	186
1905 ..	1·45	99	146	160	1·78	99	180	187
1906 ..	1·67	102	164	164	1·99	102	195	196
1907 ..	1·86	102	182	175	2·16	102	212	192
1908 ..	1·82	101	180	177	1·70	101	168	197
1909 ..	1·60	95	168	174	2·01	95	212	202
1910 ..	1·71	98	174	178	2·22	98	226	211
1911 ..	1·89	99	191	183	1·84	99	186	204
1912 ..	2·00	104	183	192	2·08	104	200	198
1913 ..	2·07	103	201	189	2·13	103	207	209
1914 ..	1·99	108	184	180	2·39	108	221	218
1915 ..	1·97	127	155	171	2·88	127	227	222
1916 ..	2·39	138	173	150	3·03	138	219	209
1917 ..	1·90	156	122	139	2·83	156	181	181
1918 ..	2·18	181	121	131	2·57	181	142	195
1919 ..	2·74	183	150	168	4·82	183	263	193
1920 ..	5·09	219	232	183	3·83	219	175	204
1921 ..	3·46	207	167	183	3·61	207	175	178
1922 ..	2·76	183	151	168	3·37	183	184	186
1923 ..	3·37	180	187	..	3·56	180	198	..

Table 3.—Proportions per Cent. of the Total Exports, 1853–1923, provided by the Main Industries of New Zealand.

(Percentages correct to nearest whole number.)

Year.	Pastoral.	Mining.	Agricultural.	Forest.	Other.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1853	22	..	6	36	36
1854	22	..	13	24	41
1855	25	..	22	4	49
1856	46	..	8	7	39
1857	48	11	5	13	23
1858	55	11	7	9	18
1859	62	5	2	11	20
1860	76	3	..	4	17
1861	38	55	..	2	5
1862	29	66	..	1	4
1863	25	70	..	2	3
1864	32	55	..	3	10
1865	31	60	..	1	8
1866	30	63	..	2	5
1867	34	58	1	2	5
1868	34	57	3	2	4
1869	32	56	2	5	5
1870	28	57	3	6	6
1871	33	53	3	5	6
1872	52	33	3	6	6
1873	50	35	2	6	7
1874	56	29	6	4	5
1875	60	24	4	3	9
1876	62	22	6	3	7
1877	62	23	4	3	8
1878	58	20	8	3	11
1879 . ..	58	19	11	4	8
1880 . ..	52	19	14	5	10
1881 . ..	49	16	15	5	15
1882 . ..	50	14	15	6	16
1883 . ..	50	11	18	8	13
1884 . ..	56	14	11	7	12
1885 . ..	58	14	8	6	14
1886	59	15	7	6	13
1887	61	12	6	7	14
1888	55	13	8	8	16
1889	57	9	11	10	13
1890	59	9	11	10	11
1891	62	11	7	10	10
1892	63	11	9	8	9
1893	62	11	6	9	12
1894	75	11	2	6	6
1895	70	15	4	7	4
1896	72	12	6	6	4
1897	72	11	5	6	6

Table 3.—Proportions per Cent. of Total Exports, 1853–1923—*ctd.*

Year.	Pastoral.	Mining.	Agricultural.	Forest.	Other.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1898	73	11	4	7	5
1899	67	14	8	7	4
1900	66	12	9	7	6
1901	62	15	12	6	5
1902	65	16	8	5	6
1903	67	15	5	6	7
1904	68	15	5	5	7
1905	70	15	3	6	6
1906	73	14	2	5	6
1907	76	12	1	5	6
1908	73	14	2	5	6
1909	74	12	5	5	4
1910	79	11	2	4	4
1911	78	11	2	4	5
1912	78	7	5	4	6
1913	81	7	1	4	7
1914	86	5	1	4	4
1915	84	7	2	2	5
1916	88	5	1	2	4
1917	88	4	1	2	5
1918	88	2	3	3	2
1919	91	3	2	1	3
1920	91	2	1	3	3
1921	93	2	1	2	2
1922	91	2	2	3	2
1923	92	2	1	2	2

Table 4.—Summary of Index Numbers.

Group Index Numbers of Wholesale Prices for the Average of the Four Chief Centres, 1913–22.

(Base: Average aggregate annual expenditure, four chief centres, 1909–13 = 1000.)

Year.	Agricultural Products.	Wool, Hides, Tallow, Butter, Cheese.	General Merchandise.	Building-materials.	Leather.	Coal.	Index of General Prices.
1913 ..	967	1047	1055	1063	1126	1038	1032
1914 ..	1021	1116	1089	1120	1184	1004	1077
1915 ..	1580	1297	1202	1217	1348	1019	1269
1916 ..	1487	1401	1317	1444	1470	1145	1380
1917 ..	1517	1466	1447	1772	1806	1369	1555
1918 ..	1845	1466	1685	2148	1900	1478	1809
1919 ..	1868	1515	1796	2067	2066	1647	1834
1920 ..	1987	1651	2340	2440	2974	2052	2185
1921 ..	1590	1576	2192	2460	2105	2228	2071
1922 ..	1430	1335	1831	2176	1773	2124	1832

Soils of the Rotorua County.

By B. C. ASTON, F.I.C., F.N.Z.Inst., Hector Medallist.

[ABSTRACT.]

IN the last volume of the *Transactions* (vol. 55, pp. 720-23) was given some account of a deficiency disease in ruminants which was proved to be caused by a lack of iron in the pasture-plants grown in the affected country, arising from the unusual soil-conditions present.

These conditions are the result of the soils having been derived from showers of material ejected from the neighbouring volcanoes or earth-vents. Where the material deposited has consisted of coarse rhyolitic pumice the soils have been of the lightest and most porous kind. These soils have not had time to become weathered and compacted by natural agencies sufficiently to enable the staple fodder plants (cocksfoot and clovers), when grown in the ordinary way on a bush burn as a surface-sown pasture, to be of sufficient nutritive value to support ruminant stock unless special treatment of the soil or animal is given. The special treatment of the soil includes (1) stumping and ploughing, thereby compacting the soil so that a given volume weighs more after ploughing than before, and thereby retaining water better; (2) applying fertilizers containing phosphates and iron; (3) a third treatment should undoubtedly be the ploughing-in of green crops (green-manuring), but experiments in this have not yet been conducted.

The special treatment of the animal consists in (1) feeding on top-dressed pasture; (2) giving extra winter feed, such as turnips and hay; (3) giving medicinal treatment when the beast shows signs of becoming anaemic; (4) supplementing the natural food of the animal, and especially that of calves and yearlings, with concentrated foods such as molasses, bran, &c. It will be argued that a good deal of what is here called special treatment is what every farmer would aim at doing on a well-ordered farm; but it must be remembered that the country is covered with forest, and that something like twenty years must elapse after a burn before the stumps can profitably be got out and the plough got in. It is this first phase of bush farming that is so fatal to the farmers on pumice lands when winter feeding is not practicable, and precautionary measures must be sought in special top-dressing of the soil, and remedial treatment in the administration of medicine supplying iron.

Where the showers have consisted of finer material, other factors—altitude, aspect, climate—being, as far as can be determined, equal, the result is a greater retention of the soil-water and the growth of a different type of forest with a distinctly different undergrowth.

When the showers have been so recent as 1886 (Tarawera Eruption), and consist of very much finer material, locally known as "mud," there results a soil having a larger proportion of fine particles and also of calcareous matter soluble in hydrochloric acid without effervescence.

It is noteworthy that the deficiency disease in ruminants only occurs in the animals depastured on the coarsest soil and not on those of finer

texture. A preliminary examination of the weight of a given volume of moist soil when the weights are all taken about the same time, so that each soil has had the same rainfall, seems to indicate that the incidence of iron-hunger varies inversely as the weight of the soil.

No. 1 type: Fine gravelly sand (Kaharoa). Rimu-tawa forest. 68·75 lb. per cubic foot. Very bush-sick.

No. 2 type: Sandy silt (Mamaku Farm). Rimu-tawa forest. 75·47 lb. per cubic foot. Not so sick.

No. 3 type: Sandy loam (Oturoa). Beech forest. 78·35 lb. per cubic foot. Not bush-sick after top-dressing.

No. 4 type: Coarse sand (Rotoiti). Rimu-tawa-mangeao forest. 79·40 lb. per cubic foot. Healthy to cattle; not bush-sick after top-dressing.

No. 5 type: Calcareous sandy loam (Te Ngae). Tutu and fern scrub. 85·81 lb. per cubic foot. Perfectly healthy country.

Weighings made of equal volumes of soil taken from ploughed and unploughed pasture-land side by side demonstrated that the land which had been ploughed was in every case appreciably heavier, showing that ploughing was an efficient method of compacting the soil. The above types of soils are arranged in the descending order in which bush sickness or iron starvation occurs on them. In No. 1 the trouble is so acute that the local practice is to change the stock twice a year. No. 2 is an average sick-country soil upon which the practice would be to change the animals once a year. No. 3 is the country of the Oturoa Road District on the beech-forest side, which is so free from the sickness that no precautions are taken; No. 4 country is sick for sheep but not for cattle. In both of these cases (Nos. 3 and 4), after top-dressing, no difficulty is experienced. No. 5 is the well-known Te Ngae district, upon which no sickness has ever been observed. Sheep (the most susceptible animal to the sickness) rear their young without difficulty, fat lambs being one of the staple products. There is, then, a graduated series of soils given in the above list commencing with "very sick" lands and leading gradually to those which are perfectly "healthy."

Another fact which emerges from a study of the large area comprised in the northern sheet of the Rotorua County map is the uniformity of these air-deposited soils over wide areas. Some 330 square miles of land have been mapped in this soil-survey, and very little variation is found in each area where running water has not had an opportunity to alter the soil by sorting the particles into river-terraces. This is only what one would expect. Districts where matter had been ejected vertically and spread by air-currents over some hundreds of square miles of country in which the physiography is such that running water cannot sort out the fine from the coarse particles would naturally alter equally over wide areas and therefore present little variation. The sandy silts therefore occupy a large area around Mamaku and extend into Matamata County, so that it is impossible at present to guess at the extent of this type. A large area of this soil extends down the Patatere plateau into the Rotorua crateriform depression, where the higher lake-terraces have been overlain by the Rotorua shower. From a soil aspect the only differences between these west and south-west Rotorua terrace soils and the Mamaku soils is that the Mamaku soils are some 1,760 ft., whereas the Rotorua terraces are only from 1,000 ft. to 1,400 ft. above the sea, thus having the benefit of lower altitude and hence of a milder climate, while the natural vegetation of the Rotorua

terraces has never been anything more difficult to "break in" to pasture than fern and manuka scrub. Hence at the very outset the farmer on terrace land had the opportunity of ploughing and compacting the soil, of manuring it with phosphates, and of growing winter feed, three very good weapons in fighting "iron-hunger."

Pumice soils, by which is meant a soil chiefly and obviously consisting of pumice, vary greatly in their quality, which is governed chiefly by their texture. This ranges from those soils which are so coarse or so elevated that they must permanently remain as desert, heath, or forest, to those which are so fine that they may be profitably utilized in the grazing of sheep and cattle. "Pumice" is a word which is supposed by etymologists to be related or derived from the same root which gives "spume" (*spuma*—foam). Pumice is, indeed, a solidified foam or volcanic froth, and highly absorbent. One finds pumice in all stages of decay, of comminution, and of compaction. It had probably been well leached before being redistributed to positions in which it is now found. The final stage of decay as pumice is where the fine lumps have become so acted upon by natural agencies that the resultant mass is plastic with very little feeling of grittiness. The final stage of comminution is when the pumice is reduced to a fine sand or silt; the final stage of compaction is found in river-terraces in which the weathered and powdered material is laid down into a wonderfully fertile alluvial soil. Soils of all these grades may be found, and what may be termed good pumice lands is where the improvement has gone on to such an extent that farming may profitably be carried on without resorting to exceptional methods. These studies are for the present limited to the soils derived from the Rotorua pumice-shower. There are many areas of pumice lands derived from other outbursts, possibly of different age, origin, and composition, which may therefore not be comparable with that of the Rotorua shower: these must be studied separately in their turn. A warning should be given against the practice of speaking of all pumice soils as a class, without limitation or definition. To make general statements disparaging to pumice soils is to court disproof by hundreds of successful farmers on what may justly be called pumice lands. On the other hand, it is dangerous to extol pumice lands indiscriminately as fields for settlement, as instances may readily be given of large areas which are not suitable for settlement by the methods in common use. Seeing that there is this great diversity of soils under the term "pumice," it will be conceded that some scheme of classification must precede an intensive study of the subject, and the initial step in this direction is exactly what a soil-survey of the Rotorua County hopes to accomplish.

In the area under discussion—the northern sheet of the Rotorua County map—the wind-borne pumice, unsorted by river or lake action, had covered a large area of rhyolitic country rock. As there is no sign of weathering or of pre-existing vegetable life at the junction of the pumice and the country rock, one suspects that the pumice fell on the rhyolite, either when recently ejected, and perhaps still hot, or while it was submerged in shallow water. One should premise the description of the Rotorua soil survey by explaining that the method of soil-classification is based on the examination of the proportion of particles present belonging to differently sized groups, each group containing particles which vary in size only within definite limits. The groups have names attached which, although in common use and therefore used loosely, in this connection are used in a technical sense and are intended to denote material of a definite

size. Thus the groups of sizes are variously designated "fine gravel," "coarse sand," "fine sand," "silt," "fine silt," and "clay." The fine gravel is the coarsest and the clay is the finest fraction. The method of separating these groups of sizes in each sample is based on the British official method, but special machinery has been devised in the Agricultural Chemical Laboratory to deal with large numbers of samples (see Grimmett, *N.Z. Journal of Science and Technology*, 1926, vol. 8, No. 2, p. 118).

The chief types of soil in the area already dealt with are,—

(1.) Sandy silt, of approximately 113 square miles.
(2.) Sandy loam, 12 square miles.
(3.) Fine gravelly sand, 37 square miles.
(4.) Coarse sand, 120 square miles.
(5.) Calcareous sandy loam, 12 square miles.

Further work will no doubt greatly extend the area of Nos. 4 and 5 types.

(1.) *Sandy Silts.*—These cover a very large extent of country west and south-west of Lake Rotorua. At the altitude of the Patetere plateau the natural vegetation is rimu-tawa (*Dacrydium-Beilschmiedia*) forest, with the exception of a patch of country described under "Sandy loam." Within the Rotorua Lake basin area, where the land rises gradually from lake-level (915 ft.) to 1,500 ft., the plant-covering is fern (*Pteridium*) and tutu (*Coriaria ruscifolia*), with occasional manuka (*Leptospermum scoparium*). The area from the west shore of the lake to the boundary of Matamata County is, with the exception of the beech-clad country of the Oturoa Road and Mangorewa-Kaharoa Block of forest reserve, essentially a soil of very definite mechanical composition, technically a sandy silt.

(2.) *Sandy loam* of the Oturoa Road and Mangorewa-Kaharoa Block: This is a distinct departure from the sandy silt series, and carries a forest the dominant trees of which are two species of beech (*Nothofagus fusca* and *N. Menziesii*). The underscrub is also characteristically different.

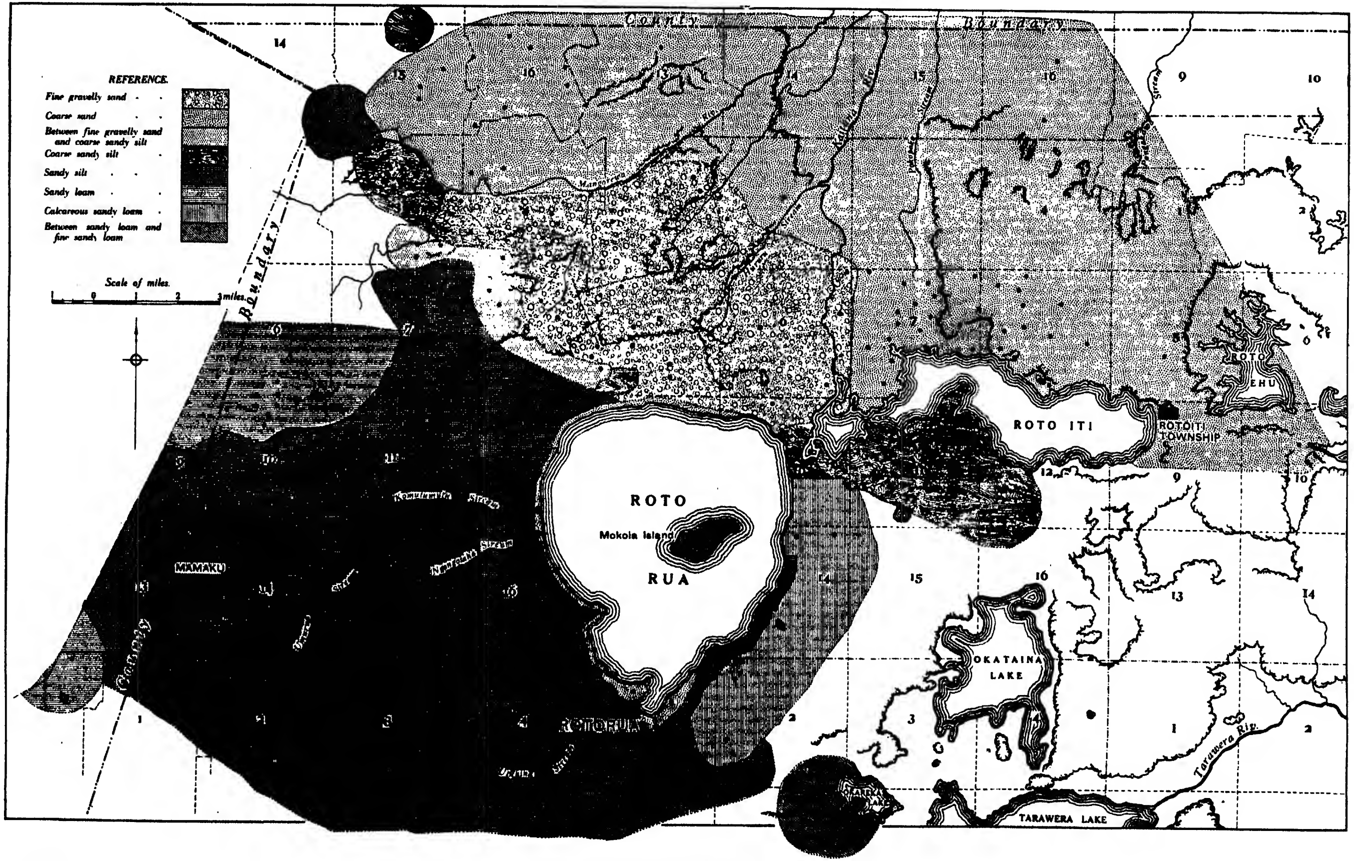
(3.) *Fine gravelly sand* occupies an area stretching from near the north shore of Lake Rotorua back to the Mangorewa River. This is the coarsest soil met with. It is very sheltered land, at a low elevation, and, although the land is affected with bush sickness worst of any, the proximity to healthy country round the edge of the lake, and also the milder climate, make for more hopeful results in farming. On the western edge of this gravelly sand is a wedge-shaped strip of intermediate material, ranging between a fine gravelly sand and a coarse sandy silt. The vegetation of this No. 3 area is forest of tawa-rimu type merging into that described under (4).

(4.) *Coarse Sand.*—To the north and east of the gravelly sand is a very large area of coarse sand which requires very detailed investigation. It is here that a detailed survey may be able to locate patches of healthy country, which will much hasten settlement. This area has been much altered by rivers, and the vegetation is the tawa-rimu type modified by the inclusion of some smaller trees requiring a milder climate than that of Mamaku, such as mangeao (*Litsaea calicaris*), kohekohe (*Dysoxylum spectabile*).

(5.) *Calcareous Sandy Loam.*—This is the area stretching from the eastern shore of Rotorua Lake to the shores of Tarawera Lake. It is free from bush sickness, and is very good sheep-country. The natural vegetation has been much altered by recently ejected material from the Tarawera Eruption, but is largely fern (*Pteridium esculentum*), with patches of rimu-tawa forest similar to that of type (3).

MAP OF NORTHERN PART OF ROTORUA COUNTY SHOWING DIFFERENT TYPES OF SOIL

The black dots show the sites whence soil samples have been drawn in the survey.



[Block by courtesy of the Editor, *Journal of Agriculture*.]

Typical mechanical analyses of the above are as follows :-

MECHANICAL ANALYSES.

(Results are percentages on air-dried soil.)

Laboratory No.	Description of Soil.	Loss on Air-drying.	Analysis of "Fine Earth" passing 2 mm. Sieve.							Stones and Gravel.
			Fine Gravel.	Coarse Sand.	Fine Sand.	Silt.	Fine Silt.	Clay.	Moisture and Loss on Ignition.	
T/525	Sandy silt	38·9	1·7	26·1	27·3	18·9	7·3	1·7	2·6 12·8	4·5
T/499	Sandy loam	38·7	0·8	16·3	20·9	19·8	8·7	5·5	9·5 18·4	Trace
T/564	Fine gravelly sand	36·4	23·2	46·6	9·9	8·7	3·5	0·9	1·4 6·5	Trace
T/606	Coarse sand	35·2	9·4	47·9	15·8	9·5	6·4	1·1	1·5 8·0	2·0
R/885	Calcareous sandy loam	31·3	4·8	21·8	28·1	21·2	9·4	5·1	1·4 7 2	10·9

T/525 from Section 12, Block 14, Rotorua, Mamaku–Rotorua Road; T/499 from Rotorua and Horohoro Blocks, Oturoa Road; T/564 from Dudley Road, Te Pu (fern slopes); T/606 from Whataroa Road, Ngawaro; R/885 from Wairoa Road (cultivated, clover).

This account does not pretend to exhaust the descriptions of soil-types occurring in this county, but aims at describing the predominant soils which are recognized in the course of a reconnaissance survey.

The work at the Mamaku Demonstration Farm has proved beyond doubt that the citrate of ammonium and iron is a cure for the deficiency disease now known as "iron-hunger," when the animal is decidedly affected. No food such as molasses, bran, or other concentrated foodstuff has been successful in curing such a beast. Molasses has been found to be of great assistance in the rearing of healthy calves. Experiments at the State Farm have demonstrated that it is possible to raise cattle on the farm and keep them free from deficiency disease. Top-dressing the pasture with phosphates has increased the iron content of the pasture when compared with that grown on unmanured parts. The best dressing for grassland is found to be a mixture of equal parts of superphosphate and basic slag, but all kinds of phosphate give a good and immediate response.

Ill-treatment of stock will, of course, predispose them to suffer from iron starvation more than when they are properly treated. Thus, as is pointed out by the writer ("Mineral Elements in the Feeding of Stock," *N.Z. Jour. Agriculture*, vol. 31, p. 351, Dec., 1925, and vol. 32, p. 78), a good supply of pure water is essential to success with cattle. A deficiency of drinking-water will interfere with the animal's digestive and other functions, and so weaken it that the beast becomes more readily affected by any other adverse conditions. Exposure to cold is also a similar weakening factor, proving the necessity for rugging cows and giving other shelter in cold or stormy weather.

An examination of the country involving a traverse along the main roads, and much careful laboratory-work, show that the soils may be clearly separated into distinct types which are uniform over wide areas. If the

physical composition only of some of these types is considered in the ligh of the experience of other countries it will be found that they would b considered too coarse for profitable occupation. Thus the compositio of the fine gravelly sand and coarse sands is such that they approach tha class of soils in England stigmatized by Hall (1911, *Jour. of Agricultura Science*, vol. 4, p. 209) as too coarse for cultivation, and therefore abandone to waste lands and commons. In America the Miami (New York) ston sand, gravelly sand, and gravel are not of much agricultural value unde present conditions. The three factors which render Hall's dictun inapplicable to the Rotorua type are (1) the greater rainfall of Rotorua (2) the porosity of the particles of pumice; (3) the rich chemical composi tion of the particles and the capacity of weathering down and becomin compacted with cultivation converts them, under the influence of plant life and the copious rainfall (almost double that of England or New York) into fertile soils.

In conclusion, the author considers that the results of the investigatio encourage the hope that the pumice lands of the Rotorua County may i the future prove of great agricultural value to the Dominion.

The following papers in the *New Zealand Journal of Agriculture* shoul be consulted for the full details of the investigation: "A Reconnaissanc Survey of Pumice Soils, Rotorua County"—1, Mamaku, vol. 29, p. 333 Nov., 1924; 2, Rotorua Basin, p. 369, Dec., 1924; 3, Kaharoa and Te Pu vol. 30, p. 1, Jan., 1925: "Iron Hunger in Ruminant Stock," vol. 30 p. 175, March, 1925. Also, in the *New Zealand Journal of Science an Technology*, vol. 7, p. 216, Nov., 1924, a paper on "Iron Starvation on th Patetere Plateau."

The Quality of New Zealand Wheats and Flours.

By L. D. Foster, M.Sc., Chemical Laboratory, Department of Agriculture Wellington.

[Abstract.]

On the whole, New Zealand wheats are good; they yield well fro healthy plants, and are well suited to local climatic conditions. Thes are important factors from the farmer's point of view. The scantiest regard has, however, been paid to the quality, or capacity to produce th best loaf of bread, of the different varieties favoured by wheat-grower in this country.

Milling Tests.

The first investigation of the milling properties of local wheats was du to the courtesy of Mr. J. C. Bruennich, Chief Chemist, Department o Agriculture, Queensland, who milled a number of samples in 1909 (*N.Z. Jour. Agric.*, 1910, vol. 1, p. 20), and again in 1912 (Aston, *N.Z. Jour Agric.*, 1912, vol. 4, p. 410). Commenting on these at the same time, Asto (*ibid.*) said that while it was not altogether fair, without knowing mor about the origin of the samples, to compare these wheats with Queenslan wheats, it might be stated that the thirty New Zealand samples tested i 1912 gave an average of 79·4 points (per 100), compared with 83·3 point

by forty-eight Queensland wheats tested in 1909, and 83·8 points by fifty samples in 1910.

Work was begun locally in 1922 by the Chemistry Section, Department of Agriculture, when milling tests were carried out with local wheat varieties, and chemical analyses made of the flours obtained. In addition, baking tests have been made in a number of cases.

The milling tests show a fairly wide variation in the percentage of flour obtained. Bruennich found the amount of flour in the New Zealand samples he milled to range from 68·1 to 76·1 per cent. Among the wheats so far tested on the Chemical Laboratory's experimental mill a range from 67·1 to 77·1 per cent has been observed.

Varieties differ considerably in the amount of flour they produce, but, owing to the influence of factors such as locality, season, soil, &c., samples within a variety differ much amongst themselves. The following table, however, calculated over three years' figures, gives the averages obtained from the better-known local varieties.

Table 1.—Averages of Flour obtained in Milling Tests on New Zealand Wheats (1923–24–25).

Variety.	Average Flour per Cent.	Number of Samples milled.
Victor	74·5	8
Tuscan	72·7	26
Hunters	72·7	8
Velvet	72·5	18

When localities are compared some fairly consistent results have been obtained from year to year, though as yet they are necessarily very incomplete; a considerable number of samples from Canterbury have now been examined, however, and a certain significance may be attached to them. Such results as the limited data allow are given in the following table:—

Table 2.—Averages of Flour obtained in Milling Tests of Wheats from certain Wheat-growing Localities.

Locality.	Average Flour per Cent. 1923.	1924.	1925.	Number of Samples.
Canterbury	73·2	72·8	73·0	69
Southland	..	70·7	70·2	7
Lake County ..	72·1	..	72·5	16

It should be possible, as information on milling tests is gradually collected, to obtain useful figures not only for land districts but even for each county, and eventually for each wheat-growing district.

QUALITY OF FLOUR.

Much work has been done on improving the yield per acre of local wheat varieties, but until the present work was initiated no very definite information was available as to their quality. Amos (*Processes of Flour-ufacture*, 1920, p. 32) includes New Zealand wheats amongst the weak varieties, but gives no details as to the basis of his conclusions.

Quality, or strength, in wheat and flour is meant to indicate possession of good breadmaking properties—that is, properties which enable the baker to produce loaves of good volume, shape, texture, and colour. Naturally,

the baking test must be the final criterion of quality, and in experimental baking tests the volume of the loaf is generally taken as the best single factor on which judgment is based. Any results obtained from analyses of flours must, if they are to be of any use, necessarily be capable of correlation with baking tests.

Protein in Flour.

It has been found in other countries that, on an average, the protein content of a wheat-flour is a fair indication of its baking-qualities; exceptions are often found, but amongst a large number of samples the above statement remains true. It applies equally to New Zealand flours (*N.Z. Jour. Agric.*, 1923, vol. 27, p. 167; 1926, vol. 32, p. 26). Moreover, different varieties are, as a whole, characterized by different average percentages of protein, though here again there are wide variations within a variety. The following table gives the average protein content of the commoner varieties tested by the Department, together with several varieties not extensively grown but nevertheless of considerable interest:—

Table 3.—Table of Averages of Protein Content of some New Zealand Wheats tested in 1923, 1924, and 1925.

Variety.	Average Protein Content per Cent.	Variety.	Average Protein Content per Cent.
Essex Conqueror ..	13·75	Yeoman	10·50
Marquis	12·40	Hunters*	10·50
Velvet*	12·19	Tuscan*	10·40
Dreadnought ..	10·73	Victor*	8·58

The more usually grown varieties are marked with an asterisk.

It may be said quite definitely that up to the present Velvet has proved the best of the better-known varieties. The little-known variety Essex Conqueror has for three years proved the best in protein content of the miscellaneous varieties grown at the Ashburton Experimental Farm. Marquis is the famous Canadian wheat. Victor, which mills excellently, is proved to produce a flour of inferior quality.

Effect of Environment (Central Otago Wheats).

The effect of environment on strength of wheat is considerable. It has long been observed that comparatively high temperatures, long days, and absence of excessive moisture during ripening hasten maturation of the grain and increase its protein content; it was to be expected, therefore, that wheats grown in the drier districts of New Zealand would show differences from the average. Such has been the case with samples of wheats tested from Central Otago. In 1923 nine samples were received from the Tuapeka and Upper Taieri (Central Otago) districts, and all were found to possess very good strength. Some of these varieties were more or less unknown to wheat-growers, but amongst them were three samples of Velvet, all of which were prominent for strength in this collection of good wheats. Again in 1925 seven samples from Lake and Vincent Counties (Central Otago) produced loaves of very good volume. These particular flours, being low in protein content, were exceptions to the general rule that good strength is associated with good protein content; nevertheless, one of them (a sample of Tuscan) produced a loaf which compared favourably

with the best of the flours yet tested. The matter of low protein content and good loaf volume is referred to later (see "Degree of Buffering").

In connection with the question of protein content it may be added that local samples of good strength have been compared with samples of wheat of accepted good strength grown in Kansas (the great wheat-growing centre in the United States) and have lost nothing in comparison (*N.Z. Jour. Agric.*, 1923, vol. 27, p. 173).

CHEMICAL ANALYSES OF FLOURS.

The baking test is, of course, the final test of quality; but even baking tests are not infallible, and it is a matter of difficulty to obtain consistent results with every sample; since all tests must, therefore, be done at least in duplicate, the process tends to become tedious. It would be a matter of importance if some chemical method could be found which would be of more general application than the present simple one of protein-determination. Various methods have been suggested at different times, and some of them have been applied to local wheats and flours. A considerable amount of work has been done locally in this connection during the last three years, and there follows a brief summary of the results obtained.

"Amended" Gliadin.—Efforts have long been made to correlate the ratio of gliadin to glutenin (the two principal proteins in wheat-flour) with strength, but without much success. Recently, however, Martin (*Jour. Soc. Chem. Ind.*, 1920, vol. 39, p. 246) has shown that previous methods of determining gliadin were faulty; he has found that flours with high bakers' marks were those in which the percentages of what he calls "amended" gliadin were high. The writer has determined the "amended" gliadin in ten New Zealand wheat-flours, and has found that, with one exception, Martin's "amended" gliadin was a fair indication of strength (results unpublished).

Ratio of Wet to Dry Gluten.—In the *International Review of the Science and Practice of Agriculture* (1922, p. 1331) it is said that the breadmaking value of a flour is determined by the following ratio:

$$\frac{\text{Moist gluten}}{\text{Dry gluten}} \times 100$$

—that is, the more water a wet gluten (the isolated crude protein) retains under certain defined conditions the better is the breakmaking value of the flour from which it is obtained. This ratio has been determined in every sample tested, but has not been found of any practical use in determining the baking-value of New Zealand flours.

Absorption of Water.—Guthrie (*N.S.W. Science Bull. No. 7*, 1912) says that the proportion of water taken up by a flour may be regarded as a good indication of strength. This is true to a certain extent with local flours, but there are so many exceptions that it has no practical value.

Composition of Ash.—The *U.S.A. Experimental Station Record* (1923, vol. 48, p. 29) gives an abstract of data from a study of North Dakota wheats which indicates that the calcium and magnesium content of the ash varies with the loaf-volume. In a series of analyses of New Zealand flour-ash no such relationship could be found (results unpublished). When, however, the percentage of these constituents was calculated on the amount of flour, and not on the amount of ash, a certain parallel was found between the amount of calcium in the flour and the amount of protein; and also between the magnesium in the flour and the amount of protein, and the

ratio of wet to dry gluten. A distinct relationship was found between the percentage of phosphoric anhydride (P_2O_5) in the flour and the amount of ash in the flour.

Colloidal State of Flours.—A great deal of attention has been directed recently to the physical chemistry of wheat-flours in an endeavour to correlate their behaviour as colloids with their baking-properties. Gortner and Doherty have done a considerable amount of work on this problem, and they say (*Jour. Agric. Research*, 1918, vol. 13, p. 389) that the hydration capacity (that is, its behaviour as a hydrophyllic colloid) of a gluten under certain well-defined conditions is closely related to its strength.

The writer investigated thirty-one samples of wheat-flour in 1925, and found that the hydration capacity (which is intimately connected with viscosity) of the moist gluten of these New Zealand flours was not any useful indication of the quality of the flour as revealed by baking tests (*N.Z. Jour. Agric.*, 1926, vol. 32, p. 93). Similar results have recently been obtained by some American investigators (*Cereal Chemistry*, 1925, vol. 2, p. 191).

Hydrogen-ion Concentration and Degree of Buffering of Flours.*—In investigating those flours which, in 1925, were found to prove exceptions to protein content being a fair indication of strength, it was found that in thirty-one wheats examined the degree of buffering of each flour was closely associated with its baking-properties. To eliminate the effect on loaf-volume of protein content, the flours were arranged first of all in series in order of approximate protein content. In each series (with very few exceptions, and these probably within the experimental error) there was a decided increase of loaf-volume coinciding with a decrease in degree of buffering. The following table, taken from one series out of a total of six, will illustrate this point:—

Table 4.—Relationship of Loaf-volume to Relative Degree of Buffering.

No.	Variety.	County.	Protein (approx.).	Loaf-volume.	Relative Degree of Buffering. †
			Per Cent.	Per Cent.	
708	Tuscan ..	Lake ..	8	700	1·4
711	Tuscan ..	Lake ..	8	670	1·3
714	Velvet ..	Vincent ..	8	650	1·2
710	Tuscan ..	Lake ..	8	620	1·1
101	Hybrid W ..	Eyre ..	8	580	0·9

The very good baking-properties of the Tuscan wheat (No. 708) from Lake County, Central Otago (mentioned in a previous paragraph), might thus be explained by its very light degree of buffering. It was found to

* The degree of buffering may be defined as the resistance to change in hydrogen-ion concentration. The buffer value of a dough is determined by several of its ingredients—proteins, milk, salt, &c.

† Change in pH of 25 c.c. of flour suspension + 2·5 c.c. N/50 hydrochloric acid: i.e., the greater the degree of buffering the smaller the change in pH and the smaller the figure in this column.

be generally true that flours more lightly buffered than the average produced good loaves even though they were low in protein content. The reverse was also true: highly buffered flours, even though possessing high protein contents, produced poorer loaves than such protein content suggested (*N.Z. Jour. Agric.*, 1926, vol. 32, p. 98). It seems that this method may give good results with local wheat-flours.

The initial pH* of flour-doughs was also investigated, but it was found that in the thirty-one samples investigated loaf-volume and initial pH of the dough were not correlated; only a slight correlation was found between initial pH and amount of ash, and between initial pH and degree of buffering. No correlation could be found between initial pH and percentage absorption of water.

SUMMARY.

Summarizing the results obtained during 1923, 1924, and 1925 with different varieties of wheats grown in New Zealand and the flours obtained from them, it may be said that—

(1.) New Zealand wheats when milled experimentally produce good amounts of flour. Some varieties produce better amounts than others; the average is 72–73 per cent.

(2.) Wheats of definitely good quality (or breadmaking value) can be grown in this country. Some of the varieties now grown produce, on an average, strong and medium-strong flours. Some of the more climatically suitable wheat-growing areas (*e.g.*, Central Otago) grow wheat which is usually of very good strength.

(3.) The protein content of local wheats is a fair average indication of their quality.

(4.) Methods of determining strength depending upon the percentage absorption of water, or on the ratios of wet to dry gluten, have little application to New Zealand flours.

(5.) Analysis of ash of flours failed to show any relationship between the amounts of calcium or magnesium in the ash and the baking-value. A certain parallel was found between the amounts of calcium and magnesium in the flour and the protein content, and between the magnesium in the flour and the ratio of wet to dry gluten. A distinct relationship was found between the amount of phosphoric anhydride (P_2O_5) in the flour and the amount of ash.

(6.) A determination of the hydration capacity (which is connected with viscosity) of gluten from New Zealand flours has not proved of any practical value in determining their baking-values.

(7.) The relative degree of buffering amongst flours of approximately the same protein content has been a good indication of baking-value, and better than any other method. Its determination should prove, with local flours at least, a useful guide to baking-values.

(8.) The initial pH of the flour-dough has so far not been an indication of baking-value.

* pH is used to express the hydrogen-ion concentration, or *intensity* factor of acidity, and is the log. to the base 10 of the hydrogen-ion concentration, the negative sign being omitted: *i.e.*, pH = log. $\frac{1}{(H^+)}$. A solution is said to be normal in respect to hydroden ions when it contains 1·0 grm. of hydrogen ions per litre. An N/10 solution of HCl is expressed as pH 1·0; exact neutrality, pH 7·0.

PROCEEDINGS.

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE.

MINUTES OF THE ANNUAL MEETING OF THE BOARD OF GOVERNORS.

27TH JANUARY, 1925.

THE annual meeting of the Board of Governors of the New Zealand Institute was held in Victoria University College on Tuesday, 27th January, 1925, at 10 a.m.

Present:—

President, Dr. P. Marshall (in the chair), and the following Governors:—

Representing the Government—Mr. B. C. Aston, Dr. Chas. Chilton, Dr. L. Cockayne, and Dr. J. Allan Thomson.

Representing Wellington Philosophical Society—Messrs. G. V. Hudson and P. G. Morgan.

Representing the Auckland Institute—Professors H. W. Segar and F. P. Worley.

Representing the Philosophical Institute of Canterbury—Professor C. Coleridge Farr and Mr. A. M. Wright.

Representing the Otago Institute—Professor J. Malcolm and Hon. G. M. Thomson, M.L.C.

Representing the Hawke's Bay Philosophical Institute—Mr. H. Hill.

Representing the Nelson Institute—Professor T. H. Easterfield.

Representing the Manawatu Philosophical Society—Mr. M. A. Eliott.

Apologies for non-attendance were received from His Excellency the Governor-General and from the Hon. the Minister of Internal Affairs.

Roll-call.—The Hon. Secretary then announced the roll.

Notices of Motion.—These were received by the President, and discussion deferred until after the adjournment.

Presidential Address.—The President then read his presidential address. On the motion of Dr. Chilton, a vote of thanks to the President for his address was unanimously carried, and it was resolved to print the address in the annual volume.

Incorporated Societies' Reports.—The annual reports and balance-sheets of the incorporated societies, as under, were received, and referred to the Hon. Treasurer and Hon. Secretary for consideration and report:—

Auckland Institute, for year ending 22nd February, 1924.
Philosophical Institute of Canterbury, for year ending 31st October, 1924.
Otago Institute, for year ending 30th November, 1924.
Wellington Philosophical Society, for year ending 30th September, 1924.
Nelson Institute, for year ending 31st October, 1924.
Hawke's Bay Philosophical Institute, for year ending 31st December, 1924.
Manawatu Philosophical Society, for year ending 31st December, 1924.

The Wanganui Philosophical Society was the only society which failed to send in a report and balance-sheet.

Report of the Standing Committee.—The annual report of the Standing Committee was then read, and considered clause by clause, amended, and adopted.

The statement of the research grants for the year was approved.

Report of the Standing Committee of the New Zealand Institute for the Year ending 31st December, 1924.

Meetings.—Eight meetings of the Standing Committee have been held during the year, the attendance being as follows: Dr. Marshall (President), 7; Mr. G. V. Hudson, 8; Mr. P. G. Morgan, 6; Dr. J. A. Thomson, 5; Hon. G. M. Thomson, 1; Professor C. C. Farr, 1; and Mr. B. C. Aston, 8.

Hector Award.—The award for 1923 was made to Dr. D. Petrie, on account of his pioneer investigations of the distribution of the plants of Otago and Stewart Island, which brought forth much information essential for New Zealand plant geography, together with his further botanical explorations in most parts of the North and South Islands carried out year by year since 1876, and his many contributions towards a more accurate knowledge of the flora of New Zealand.

At a meeting of the Council of the Auckland Institute held on the 3rd April the President, Mr. Gunson, Mayor of Auckland, presented the Hector prize and medal to Dr. Petrie.

Publications.—*Transactions of the New Zealand Institute:* Volume 54 (1921), after much delay, was received from the Government Printer on the 29th January, 1924. Volume 55, which is a combined volume for the years 1922 and 1923, was issued by the Government Printer on the 30th October, and sent out to societies and exchanges in November. Volume 54 was laid on the tables of the Legislative Council on the 3rd July, and the House of Representatives on the 16th July. Volume 55 was received too late to be presented last session.

Bulletins.—At present in the press is the last part of Dixon's Bulletin on the *Bryology of New Zealand*, authorized on the 10th October by the Standing Committee to be printed, at a cost of £80 for 500 copies. With the issue of this part Bulletins Nos. 1, 2, and 3 will be complete, and parts or complete sets may be obtained on application. Prices of the foregoing are quoted on the covers of the *Transactions*.

Exchange List.—During the year the following additions have been made to the exchange list: Voronesh University; Royal Technical University, Stockholm; La Société Botanique de Pologne; Real Sociedad Espanola de Historia Natural, Madrid; University of Missouri. A circular drawn up by the Exchange Committee and approved last year has also been sent to over two hundred institutions with a view to an exchange of publications, and from the replies so far received is meeting with very favourable consideration.

Sales.—Some sets of *Maori Art*, partial sets of *Transactions*, and a few *Bulletins* have been disposed of, as well as a few sets of C. R. Carter's books, the latter being credited to the Carter Bequest Revenue Account.

Incorporated Societies' Reports and Balance-sheets.—The following reports and balance sheets have been received, and are now laid on the table:—

Auckland Institute, for year ending 22nd February, 1924.
Philosophical Institute of Canterbury, for year ending 31st October, 1924.
Nelson Institute, for year ending 31st October, 1924.
Otago Institute, for year ending 30th November, 1924.
Wellington Philosophical Society, for year ending 30th September, 1924.
Hawke's Bay Philosophical Institute, for year ending 31st December, 1924.
Manawatu Philosophical Society, for year ending 31st December, 1924.

Fellowship, New Zealand Institute.—On the 6th March the election to the Fellowship of the New Zealand Institute of W. H. Guthrie-Smith, Esq., and Dr. R. J. Tillyard was gazetted. On the 8th April the incorporated societies were asked to forward nominations for filling the two vacancies for 1924. Ten nominations came to hand, and were submitted to the Fellows of the Institute for selection. On the 29th October the results of the selection were submitted to the Governors.

Carter Bequest.—At a meeting of the Standing Committee held on the 4th March it was resolved that a Carter Bequest Committee be set up to discuss the terms of the resolution carried by the Board of Governors on the 29th January relative to the Carter Bequest, the committee to consist of four members of the Institute, two Wellington City Councillors, and two members of the Astronomical Section of the Wellington Philosophical Society; the committee to report to the Standing Committee and the various bodies interested. The following were subsequently appointed to act on this committee:—

Representing the Institute—Dr. Marshall, Professor Kirk, Messrs. Eliott and Hudson.
Representing the City Council—Councillors Forsyth and Meadowcroft.
Representing the Astronomical Section—Drs. Hector and Adams.

The first meeting of this committee was held in Victoria College on the 8th April, when the following resolutions were passed:—

"That the City Council be asked to grant the New Zealand Institute a tenure in perpetuity, or as long as an astronomical observatory is erected upon it, of the site referred to in the Wellington City Empowering Act, 1922."

"That Professor Kirk be asked to draft for the Chairman's approval and signature a letter to the Town Clerk setting forth the proposal of clause C* of the resolution carried at the annual meeting of the New Zealand Institute, 1923, and that a copy of the letter be sent to each Councillor; also that Professor Kirk, or the Chairman, be asked to attend before any committee of the Council that may consider the matter."

A letter embodying the above resolutions was accordingly forwarded on the 26th April to the Town Clerk, and on the 28th April a copy of the same letter was sent to each of the City Councillors. On the 9th July the Town Clerk acknowledged receipt of the letter, stating that matters contained therein were under consideration, and that in the meantime the Meanee telescope had been handed over in trust to Dr. C. E. Adams, Government Astronomer, for setting up in a temporary building then being erected near the Observatory at Kelburn. No further communication has been received on the matter.

Storage of Stocks.—The Internal Affairs Department has kindly placed at the disposal of the Institute a room in the basement of the old Parliament Buildings, recently vacated by the Department, and most of the stocks of publications have already been transferred there. When these seventeen thousand volumes have been classified and placed on the shelving provided they will be in a much more convenient and satisfactory state than has prevailed for years, but the work is heavy and can be done only at intervals.

* Clause C referred to is as follows:—

"That, provided the City Council donate the municipal telescope to the Institute as trustees of the Carter Fund, there be built a Carter Memorial Observatory at the expense of the Carter Fund; that the observatory be under the control of the New Zealand Institute, the Wellington City Council, and the Astronomical Section of the Wellington Philosophical Society."

Carter Library Legacy.—At last annual meeting the Standing Committee was asked to inquire further into the matter of the Carter legacy retained by the Public Trustee, and which was earning only 3 per cent. As 3 per cent. is the usual rate allowed on amounts at call, and as there was no possibility of the fund being utilized in the near future, on the 5th June the Standing Committee gave the Public Trustee an undertaking that the capital would not be required for five years, and the Public Trustee agreed to allow interest at the rate of 5 per cent.

Dominion Museum.—The resolution passed at last annual meeting was conveyed to the Hon. the Minister of Internal Affairs, and the outlook for a new building is decidedly brighter. Cabinet proposed to give a subsidy of £75,000 provided the citizens of Wellington raised a similar amount. Subsequently, on a proposal to include an art gallery with the Museum, the amount promised by the Government was raised to £100,000.

Research Grants.—As an outcome of a resolution of the Board at last meeting, a deputation waited upon the Hon. the Minister of Internal Affairs with regard to the re-establishment of the research-grant vote. The Hon. the Minister was sympathetic, and informed the deputation that the Institute would be agreeably surprised at the amount which he proposed to ask Cabinet to grant for this purpose. On the 13th March a communication was received from the Hon. the Minister intimating that £1,000 had been placed on the estimates for a research vote, to be administered by the Institute. On the 19th March the incorporated societies were advised by circular that this amount was available, and were asked to bring the matter before their members. Nineteen applications for grants were received, and ten of these were recommended to the Hon. the Minister for approval.

Catalogue of Scientific Journals.—Mr. Archey, who has the preparation of the catalogue in hand, during the year sent to all the scientific libraries in New Zealand a copy of the catalogue to be revised. When this revision is completed the catalogue can be finally typed or printed, and libraries may obtain a copy.

Binding.—During the year a complete set of the Institute's *Transactions* have been bound in brown buckram for the library, and the Standing Committee at its meeting on the 16th September agreed to the Library Committee's recommendation that up to £100 out of the special fund in hand be expended on binding the publications of the London Royal Society and £50 on New Zealand publications.

Finances of the Institute.—At a meeting of the Standing Committee held on the 6th September the Hon. Secretary submitted certain proposals which would result in placing the finances of the Institute on a more secure foundation. It was resolved to place the matter in the hands of the President and Hon. Secretary to report further.

National Research Council.—Arising out of a resolution carried by the Board at its last meeting, the President drew up the following report showing how the functions of National Research Councils elsewhere are at present fulfilled by the New Zealand Institute:—

"The object of a National Research Council is—(1) To co-ordinate national efforts in the different branches of science and its applications; (2) the investigation of a number of special problems by the aid of grants to investigators; (3) the encouragement and development of research by the organization of research workers.

"The number of research workers in New Zealand is necessarily small, and they are scattered. In each centre there is a society affiliated to the New Zealand Institute which meets regularly for the discussion of any scientific matters that are the subject of research of any of the members, who practically constitute all the scientific workers of the district. Representatives of these societies meet annually in Wellington, when they consider reports from the different societies. Those representatives that are available in Wellington constitute the Standing Committee, and meet regularly between the periods of the annual meetings and deal with any matters referred to them by the individual societies. This we believe is the most satisfactory way within the limits of the possibilities of the Dominion conditions to co-ordinate scientific research work in the country.

"The Standing Committee receives reports from the various affiliated societies of persons who are qualified and ready to undertake research of any kind. Where suggested research coincides with or duplicates work that has been undertaken elsewhere the society concerned is informed and necessary action is taken. Also, apparatus and material that has been used by one investigator whose work is completed is sent on to another who may require it.

"The Standing Committee, after considering applications for grants from the various research workers, decides whether the subject of research and the applicant justify expenditure, and, if so, it allots a certain sum from the Government research grant which it considers sufficient to meet the expenses that are necessarily incurred in conducting the research.

"We consider that by acting in this way the Institute is in effect acting the part of a National Research Board for the Dominion."

Tongariro National Park.—At last annual meeting the following resolutions—"That this Board strongly opposes the planting of heather on any part of the Tongariro National Park or any other scenic reserve"; and "That no leasing of any portion of the National Park be allowed"—were forwarded to the Hon. the Minister of Lands, who replied that he was forwarding them to the Chairman of the Tongariro National Park Board.

On the 10th October a letter was read from the Manawatu Philosophical Society protesting strongly against the introduction of any exotics into the park. On the 19th November a deputation organized by the Tararua Tramping Club waited upon the Minister of Lands and the Park Board to protest against heather and grouse being introduced into the park, and against the selection of the Haunted Whare site for the new hostel. Professor Kirk and Mr. G. V. Hudson represented the Institute on this deputation.

On the 18th November the Standing Committee passed the following resolution: "That in the opinion of the New Zealand Institute the Tongariro National Park should be absolutely reserved as a sanctuary for native plants and animals."

Stewart Island.—A resolution passed at the annual meeting in January last, urging that the control of the animal-life on Stewart Island should be retained by the Government and should not be allowed to pass into the hands of any acclimatization society, was conveyed to the Hon. the Minister of Internal Affairs, and on the 30th April the Minister replied and asked for details as to how the Institute would suggest that its wishes could be carried out.

At a meeting of the Standing Committee held on the 5th June a sub-committee, consisting of Professor Kirk and Messrs. Oliver and H. Hamilton, was appointed to go into the matter. On the 19th December this committee sent in the following report, which was read at a meeting of the Standing Committee held on the 23rd December, when it was resolved that the Hon. the Minister be replied to and given the recommendations of the committee:—

"The committee set up to consider the matter of protection of plant and animal life on Stewart Island reports as follows:—

"Nearly the whole of Stewart Island is Crown land, and is reserved either as scenic reserves or as forest reserves. It would appear, therefore, that the status, from the point of view of the Institute, is not unsatisfactory, although an improvement would perhaps be effected if the whole of the Crown lands on the island were declared a permanent forest reserve.

"The correspondence shows that deer are present in numbers. It is in the interests of the country, and especially in the interests of the State Forest Service, that they should be exterminated. They not only kill trees, but they keep down the undergrowth and prevent regeneration, thus setting a limit to the life of the forest.

"Experience shows that it will probably be extremely difficult to get the seriousness of the position recognized by the Government. Pending decisive action by the Government, the committee recommends that Government regulation should make it a serious offence for any one licensed to shoot on a reserve, on Stewart Island or elsewhere, to have on the reserve a fowling-piece or any rifled firearm with a bore less than ·303. In the absence of fowling-pieces and pea-rifles, the destruction of bird-life would be much lessened.

"As such a regulation as that just referred to would probably not be binding on the Maori on mutton-birding expeditions, it is suggested that the Institute should draw up and circulate among the Maori of Stewart Island and elsewhere a statement of the main facts, and an appeal for the native plants and animals.

"Signed on behalf of the committee.

"H. B. Kirk."

Australasian Association for the Advancement of Science.—On the 2nd August the Standing Committee appointed Professor Sommerville and Mr. A. M. Wright to represent the Institute at the Adelaide meeting of the Australasian Association for the Advancement of Science, and is was resolved to ask those delegates to report on the proposals for widening the functions of the association as submitted by the General Secretary of the association.

On the 17th September the following report was received from Professor Sommerville and Mr. Wright:—

"The matter contained in the circular issued by the permanent Secretary of the Australasian Association for the Advancement of Science relating to the proposed widening of the functions of the association was brought up at a meeting of the Council in Adelaide, and the following committee was appointed to inquire and report on the suggestions: Sir George Knibbs, Sir John Monash, Sir Baldwin Spencer, Mr. Andrews, Mr. L. Keith Ward, and Dr. H. C. Richards.

"Other resolutions of interest which were passed are as follows:—

"(1.) In future Vice-Presidents of the association shall consist of members domiciled in Australia or New Zealand, with the exception of the founder, Professor Liversidge.

"(2.) Professor H. B. Kirk was appointed joint Local Secretary for New Zealand with Professor C. Coleridge Farr.

"(3.) The Mueller Medal was awarded to Mr. Andrew Gibb Maitland for his eminent services in the cause of geology.

"(4.) The places and dates for the next two meetings were decided as follows: August, 1926, Perth; January, 1928, Hobart.

"(5.) Sir Thomas Lyle was appointed President for the meeting in 1926.

"(6.) The proposal, received at the last meeting at the instance of the Department of Internal Affairs of New Zealand, that the name of the association be changed to the 'Australian and New Zealand Association for the Advancement of Science' was negatived, but it was resolved that future correspondence paper of the association should have the words 'Australia and New Zealand' inscribed on it, in brackets, underneath the present title."

Scientific Visits to Pacific Islands.—At a meeting of the Standing Committee held on the 23rd December the following letter was received:—

"The Hon. Secretary, New Zealand Institute.

"DEAR SIR,—

"In 1924 the Minister of Defence extended to New Zealand scientists, on application of the Board of Science and Art, the privilege of travelling between various Pacific islands on H.M.S. 'Veronica' and 'Laburnum,' the cruises of which take place from June to October. The Minister now advises that similar facilities will be accorded to approved scientists on future occasions whenever the exigencies of the service will permit. No cabin accommodation is, as a rule, available in His Majesty's ships, and the total number to be accommodated should not exceed four persons.

"Applications for accommodation should be forwarded not later than the middle of March, annually, as it is necessary to arrange the itinerary of His Majesty's ships to the islands of the South Pacific by the end of the month.

"Yours faithfully,
"J. ALLAN THOMSON,
"Secretary, Board of Science and Art."

Resolutions not otherwise mentioned in the Report.

1. On the 4th March it was resolved that the price of *Bulletin No. 3*, part 3, be 3s. 6d. to members and 4s. to non-members.

2. On the 5th June it was resolved to grant Mr. Dixon fifty extra copies of his *Bulletin No. 3*, part 3.

3. On the 16th September it was resolved to discontinue printing the Roll of Honour in the *Transactions.*

4. On the 18th November it was resolved that the price of back numbers of the *Transactions* to booksellers be the same as that to non-members, and that no discount be allowed. (See resolution of annual meeting.)

Arising out of the Standing Committee's report:—

National Research Council.—Proposed by Dr. J. A. Thomson, seconded by Dr. Chilton, and carried, That the President be requested to communicate with the Australasian Association for the Advancement of Science, the Pan-Pacific Congress, the National Research Councils of Australia, America, and Japan, and other similar bodies, informing them that the New Zealand Institute carries out the functions of the National Research Council for New Zealand.

Stewart Island Sanctuaries.—Proposed by Dr. Cockayne, seconded by Professor Segar, and carried, That a committee be set up to suggest to the Standing Committee, who shall have power to act, the setting-aside of more scenic reserves in Stewart Island.

Publications Committee.—Proposed by Dr. J. A. Thomson, seconded by Dr. Cockayne, and carried, That the Standing Committee, with the addition of the Hon. Editor, be the Publications Committee.

Tongariro National Park.—The President read his report on the Tongariro National Park Board.

REPORT OF TONGARIRO NATIONAL PARK BOARD.

The Board has held the customary quarterly meetings during the year, and much discussion has taken place in regard to the site of the proposed hostel. The Board decided on the Haunted Whare site.

A road has been cleared through the tongue of bush between the Haunted Whare and Whakapapa huts.

The Prisons Department is still cutting timber on the south slopes of Hauhangatahi. They are restricted to those trees that have been previously marked. Care is taken to prevent fire.

The liberation of grouse was done without previous authority from the Board. As your representative, I moved at the last meeting, "That this Board regards the Tongariro National Park as an absolute sanctuary for New Zealand fauna and flora." An amendment was moved to the effect that no exotic plants or animals were to be introduced without previous authority of the Board. The amendment was carried by a narrow majority. This perhaps is an improvement on the previous position, though I think the present state of affairs is not satisfactory to those who wish the park to maintain its distinct national character. This I fancy is the wish of all nature-lovers and of many others who have a general national interest.

P. MARSHALL,
President, New Zealand Institute.

On the motion of Dr. Chilton, it was resolved, That the report be received, and the President thanked for it.

On the motion of Professor Easterfield, seconded by Mr. Hill, it was resolved, That this meeting of the Board of Governors of the New Zealand Institute, containing delegates from all the scientific societies in New Zealand, unanimously protests against the introduction of any plants and animals other than natives of New Zealand into the Tongariro National Park.

Great Barrier Reef Committee's Report.—This report was received, and on the motion of Dr. Thomson, seconded by Dr. Cockayne, it was resolved, That Mr. Oliver be thanked for his report, and reappointed the Institute's representative on the Great Barrier Reef Committee.

REPORT OF GREAT BARRIER REEF COMMITTEE.

The operations for the past year include twelve meetings of the committee.

Reports were received from Commander Maxwell, R.N., on soundings in the reef region, and from Mr. H. Tyron, Queensland Government Entomologist, on the economic products of the reef.

Mr. Charles Hedley was appointed full-time Scientific Director to the committee from the 1st April, 1924, at a salary of £500 per annum. A plan for the future work was submitted by Mr. Hedley, and his suggestions were adopted by the committee.

The publications of the committee during the year include the following papers: "Geological Reconnaissance in Northern Queensland"; "Emergence at Holbourne Island"; "Natural Destruction of a Coral Reef"; "Temperature Observations at Wallis Island."

The Scientific Director has reported on the following subjects: "A Raised Beach at the North Barnard Islands"; Coral Shingle as a Beach Formation"; "The Townsville Plain"; "An Opacity-meter."

Boring proposals submitted by Professor Richards have been circulated to members of the committee and to various geologists for comments and suggestions.

Financial statement shows—Receipts, £2,317 0s. 5d.; expenditure, £453 17s. 10d.: balance in hand, £1,863 2s. 7d.

W. R. B. OLIVER,
New Zealand Institute Representative on the committee.

Dominion Museum and Art Gallery.—On the motion of Dr. Chilton, seconded by Professor Worley, it was resolved, That the Government be urged to bring in a Bill placing the control of the Dominion Museum and Art Gallery in the hands of a Board of Trustees.

Pan-Pacific Food Congress.—This report, by the Hon. G. M. Thomson, was read and received.

PAN-PACIFIC FOOD CONGRESS, HONOLULU: REPORT BY G. M. THOMSON.

As an outcome of my visit to Honolulu in July–September of last year as New Zealand delegate to the Pan-Pacific Food Conservation Congress, two matters of scientific importance outside the scope of the conference arrested my attention, and I desire to ask the co-operation of the New Zealand Institute in urging these upon the notice of the Government.

The question of establishing a vulcanological observatory in the North Island of New Zealand has been under consideration for the past four or five years, but so far no definite action has been taken. I recently revived the subject in a letter to the Minister of Internal Affairs, dated 8th November, 1924. A copy of this is filed in the Dominion Museum. The latest proposal is a resolution of the New Zealand Board of Science and Art, passed at its meeting of 3rd October, 1924, as follows:—

"That, in view of the fact that the geological structure of the thermal regions is still very imperfectly known, the committee consider that the first step towards a permanent vulcanological observatory should be the appointment of a full-time research officer to make geological and vulcanological observations for a period of two years under the direction of the Board. The committee recommend that the officer should be appointed by the Board, at a salary of £400, be furnished with a motor-car, and receive mileage expenses."

I suggest that the Institute at its annual meeting should support this proposal, and ask the Government to take action at as early a date as possible.

The second matter is the desirability of fitting the vessels of the New Zealand naval and marine services with sonic depth-finders, and is embodied in a letter to the Minister of Marine. The importance of this subject is twofold. First, in view of the development of a Fishery Department, which the Government is now undertaking, it is very desirable that a detailed survey of the costal region within the 100-fathom line should be undertaken. This could be done by the smaller vessels of the service—*e.g.*, the "Veronica" and the "Laburnum," and also the "Tutanekai." Ultimately, contour maps of the whole area could be prepared. Secondly, if the larger vessels of the naval service—*e.g.*, H.M.S. "Dunedin"—were fitted with sonic depth-finders, it would be possible to obtain a complete bathymetrical survey of the deep fissure which lies approximately along the line between the volcanic region of the North Island of New Zealand and the Islands of the Tongan and Somoan groups. Information on this matter would be most valuable in connection with the work of the volcano observatory. The United States Navy would probably supplement this work later by a similar survey of the line between Samoa and Hawaii.

The Council of the Institute would be furthering a great Imperial as well as international scientific research if it succeeded in moving the New Zealand Government to take action in these two directions, and I have therefore much pleasure in suggesting that it give the whole subject its fullest consideration.

GEO. M. THOMSON.

Sonic Depth-finders.—The following resolution, proposed by the Hon. G. M. Thomson, seconded by Dr. Chilton, was carried: That the Government be urged to furnish vessels of the New Zealand Naval Service with sonic depth-finders to enable them to carry out a bathymetrical survey of the seas round New Zealand and of the deep-sea area between New Zealand and Samoa.

Geological and Vulcanological Research.—On the motion of the Hon. G. M Thomson, seconded by Professor Easterfield, it was resolved, That

the Government be asked to give effect to the recommendations of the Science and Art Board that a full-time research officer should be appointed to make geological and vulcanological observations in the volcanic region of the North Island.

Price of Transactions.—On the motion of Dr. Cockayne, seconded by Dr. Thomson, it was resolved, That volumes of the *Transactions* of which there is a sufficient stock, as quoted on the cover of the volumes at 5s. per volume to non-members, be sold to booksellers at 3s. 6d. per volume.

Publications Committee's Report.—The report was read and received. A special vote of thanks was unanimously accorded to the Hon. Editor for his labours during the year.

REPORT OF PUBLICATIONS COMMITTEE.

The volume for the two years ending 31st December, 1923, was issued in one volume of 18 + 884 pages (of which 157 pages were Proceedings and Appendix), with 71 plates (one coloured), and the usual illustrative text-figures. The volume contains sixty-one papers by forty-two authors, the papers for the two years being kept separate. The publications of the Institute are now up to date, a further instalment of Dixon's "Mosses" received during the year being in the hands of the printer.

Owing to a notice sent to the affiliated societies informing them that the rule that no papers received after the 31st December would appear in the current volume, most of the papers were sent immediately after reading, so that preparation of Volume 56 is already well in hand, and it is hoped that it will be issued in the first half of 1925.

For the committee.

JOHANNES C. ANDERSEN.

Hon. Librarian's Report.—This report was read and received. It was resolved to accept Professor Kirk's resignation with regret.

REPORT OF HON. LIBRARIAN.

The Institute did me the honour to appoint me Honorary Librarian. I wish I could make a report that would show that I had proved worthy of the honour, but I cannot. All the good work that has been done in the library has been done by Miss Wood, who has shown herself very zealous and competent. I have done nothing. I had a great many good intentions—so many that the Board, if it knew of them all, would naturally conclude that I had spent the year in preparing a motor-road to my final destination. If I could get time for the important work of the library I should be glad to continue in office, but I cannot. I ask, therefore, that the Board will appoint some one that can and will.

H. B. KIRK.

Hon. Treasurer's Report.—This report was read and received, and the following statements, duly audited by the Auditor-General, were adopted :—

(*a.*) Statement of Receipts and Expenditure.
(*b.*) Statement of Assets and Liabilities.
(*c.*) Statement of Research Grants.
(*d.*) Statement of Carter Bequest.
(*e.*) Statement of Hector Memorial Fund.
(*f.*) Statement of Hutton Memorial Fund.
(*g.*) Statement of Hamilton Memorial Fund.

On the motion of Dr. Marshall, seconded by Professor Worley, the following resolution was carried: That the annual grant received by the New Zealand Institute from the Government is entirely inadequate for the requirements of the Institute, being no more than the salary of many a Government official. Owing to the increase in the work of the Institute and to the very large increase in the cost of publishing the *Transactions*, the Institute is less liberally treated at the present time than it was forty years ago. The Board of Governors believes that the Government cannot be aware of the disabilities under which the New Zealand Institute is

labouring, or of the importance of the work being carried out by the Institute, and hereby resolves that a committee of the Board shall wait upon the Hon. the Minister of Internal Affairs and request that the annual grant be increased to £2,000.

It was resolved that the President and Messrs. Aston, Eliott, Hudson, Morgan, and the Hon. G. M. Thomson be a committee to wait on the Hon. the Minister to present this resolution.

Hon. Treasurer's Report.

At the last annual meeting, owing to no anticipatory liability having been shown for printing Volume 54, the finances appeared to be in a satisfactory condition. This meeting, however, has to face quite a different position; and in consequence of the Government Printer's charges for both Volumes 54 and 55 being debited in the present balance-sheet the credit balance of £869 15s. 3d. on the 1st January, 1924, has been turned into a debit balance of £1,122 12s. 10d. on the 1st January, 1925.

Owing to the late appearance of Volume 55, the incorporated societies did not receive their copies and relative accounts until last month, therefore only two societies have paid their levies. There should be about £236 to come in from this source, but this has been taken into consideration in the balance sheet.

It will also be seen that the Government Printer's account for Volume 55—£1,518 19s.—has increased by over £163 as compared with the cost of Volume 54—£1,355 10s.—although Volume 55 had only 884 pages as against 920 in Volume 54. In 1914 the Government Printer's account for Volume 45 (419 pages) was £334, a cost of under 16s. per page, as compared with £1 14s. 7d. per page for Volume 55, an increase of over 115 per cent.

The position is a serious one, and it will be necessary thoroughly to discuss it, and, if possible, arrive at a decision on the question of the finances, at the annual meeting.

It is obvious that with the annual cost of printing the *Transactions* now amounting to over £1,500, and other expenses, say, £500, totalling £2,000, and on the other hand the statutory grant of £1,000, and other sources, say, £350, total £1,350, it means that the Institute must show a loss of about £650 per annum.

There appears to be only four ways by which the position can be remedied: (1) Cut down the size of the volume by more than half, or issue it every two years instead of each year: (2) obtain an increased grant from the Government; (3) charge the incorporated societies the increased cost of the *Transactions*; (4) find some cheaper means of printing the *Transactions*.

The various trust accounts continue to show a very satisfactory condition. The Carter Bequest revenue has increased from £320 17s. 3d. in 1923 to £339 6s. 3d. in 1924; the revenue earned is equal to 6·21 per cent. The capital has now grown to £5,754 12s. 11d.

Up to the present no action has been taken regarding the resolution carried at the last annual meeting to spend £3,000 on the building of an observatory in Welllington.

The books and accounts have, as usual, been well and accurately kept by the Assistant Secretary.

M. A. Eliott,
Hon. Treasurer.

New Zealand Institute.—Statement of Receipts and Expenditure for Year ending 31st December, 1924.

Receipts.	£	s.	d.
Balance as at 31st December, 1923	2,105	6	11
Petty cash in hand, 1st January, 1924	10	8	8
Publications sold (authors' copies)	92	5	8
Statutory grant, 1924	1,000	0	0
Interest, Carter Bequest	338	15	0
Interest, Hector Memorial Fund	68	10	0
Interest, Hutton Memorial Fund	58	10	0
Interest, Hamilton Memorial Fund	3	7	6
Interest on Endowment Fund invested	10	0	0
Interest, Post Office Savings-bank (Endowment Fund)	61	11	5
Interest on Carter legacy	1	10	0
Levy on Volume 54	188	5	0
Levy on Volume 55	44	15	0
Research grants paid by Department of Internal Affairs	166	0	0
Research grant—Balance refunded	0	4	8
	£4,149	9	10

Expenditure.	£	s.	d.
Government Printer	1,100	0	0
A. A. Lawson (plate)	29	5	4
Adlard, Son, and West, Newman	2	6	0
C. M. Banks (letter-book)	1	2	6
Travelling-expenses	60	8	2
Charges (bank commission, insurance, &c.)	7	11	0
Salary	283	6	8
Petty cash (postages, &c.)	13	8	9
Binding library books	15	4	4
Library shelving, cabinet, &c.	17	5	3
Hector Prize, 1923	45	0	0
Hector Prize, 1924	45	0	0
Carter interest invested	298	19	11
Interest on trust funds transferred to accounts	105	7	5
Research grants	431	1	9
Balance, as under	1,694	2	9
	£4,149	9	10

	£ s. d.	£ s. d.
Balance in Bank of New Zealand	242 11 8	
Less unpresented cheque	30 0 0	
		212 11 8
Balance in Post Office Savings-bank	..	1,474 11 2
Petty cash in hand	..	6 19 11
	..	£1,694 2 9

Made up as follows—	*Dr.* £ s. d.	*Cr.* £ s. d.
Library Fund	..	230 10 8
Government Research Grant Fund	..	706 8 7
Carter Bequest—Revenue Account	..	82 11 6
Hector Memorial Fund—Revenue Account	27 13 8	..
Hutton Memorial Fund—Revenue Account	..	80 2 7
Hamilton Memorial Fund—Revenue Account	..	1 9 7
Endowment Fund—Revenue Account	..	135 5 9
Carter Legacy—Interest	..	3 15 0
Government Printer	..	2,020 18 5
Amount overdrawn, Hamilton Fund	0 3 11	
Sundry debtors	236 18 11	
Deficit on year's work	1,122 12 10	
Carter Bequest—Post Office Savings-bank Account	82 11 6	
Hector Memorial Fund—Post Office Savings-bank Account	15 6 4	
Hutton Memorial Fund—Post Office Savings-bank Account	80 2 7	
Hamilton Memorial Fund—Post Office Savings-bank Account	1 9 7	
	£1,566 19 4	£3,261 2 1
		£1,566 19 4
		£1,694 2 9

NEW ZEALAND INSTITUTE.—STATEMENT OF ASSETS AND LIABILITIES AS AT 31ST DECEMBER, 1924.

Liabilities.	£	s.	d.
Carter Bequest—Capital Account	5,754	14	11
Hector Memorial Fund—Capital Account ..	1,184	18	1
Hutton Memorial Fund—Capital Account ..	1,014	5	10
Hamilton Memorial Fund—Capital Account ..	48	7	11
Endowment Fund—Capital Account ..	198	19	4
Carter Bequest—Revenue Account ..	82	11	6
Hutton Memorial Fund—Revenue Account ..	80	2	7
Hamilton Memorial Fund—Revenue Account	1	9	7
Endowment Fund—Revenue Account ..	135	5	9
Library Fund	230	10	8
Government research grants	706	8	7
Interest on Carter legacy of £50	3	15	0
Government Printer	2,020	18	5
	£11,462	8	2

Assets.	£	d.	£	s.	d.
Inscribed stock, Discharged Soldiers Settlement Loan, £7,650 .			7,068	2	11
Post Office inscribed stock, £1,100			1,084	15	3
Government war bonds, £50			48	11	10
Hector Memorial Fund—Revenue Account			27	13	8
Petty cash in hand			6	19	11
Cash in Post-office Savings-bank			1,474	11	2
Cash in Bank of New Zealand	242	8			
Less unpresented cheque	30	0			
			212	11	
Cash in Post-office Savings-bank—Carter Bequest Account .. .			82	11	
Cash in Post-office Savings-bank—Hector Fund Account .. .			15	6	
Cash in Post-office Savings-bank—Hutton Fund Account .. .			80	2	
Cash in Post-office Savings-bank—Hamilton Fund Account .. .			1	9	
Sundry debtors			236	18	11
Balance of liabilities over assets			1,122	12	10
			£11,462	8	2

Examined and found correct. — G. F. C. CAMPBELL, Controller and Auditor-General.

M. A. ELIOTT, Hon. Treasurer.

NEW ZEALAND INSTITUTE.—GOVERNMENT RESEARCH GRANTS FOR YEAR ENDING 31ST DECEMBER, 1924.

			Dr. £	s.	d.	*Cr.* £	s.	d.
Jan. 1.	By	Balance	..			971	5	8
Jan. 21.		Treasury	..			100	0	0
Dec. 15.		Refund, Dr. Curtis ..	..			0	4	8
Dec. 19.		Treasury	..			30	0	0
Dec. 19.		Treasury	..			6	0	0
Dec. 19.		Treasury	..			30	0	0
Jan. 23.	To	Professor Easterfield ..	100	0	0	..		
Mar. 5.		Dr. Inglis ..	25	0	0	..		
Mar. 5.		Professor Speight ..	50	0	0	..		
April 12.		H. Hamilton	10	0	0	..		
June 27.		Dr. Malcolm	10	0	0	..		
July 18.		J. G. Myers	10	0	0	..		
July 18.		H. J. Finlay	27	1	10	..		
Aug. 22.		E. K. Lomas	24	16	4	..		
Aug. 28.		Dr. Marsden	32	14	10	..		
Oct. 17.		Dr. Malcolm	10	0	0	..		
Nov. 25.		Artesian Wells Committee	32	11	6	..		
Nov. 25.		W. J. Phillipps ..	6	0	0	..		
Nov. 25.		H. J. Finlay	10	0	0	..		
Dec. 7.		Dr. C. C. Farr	7	17	3	..		
Dec. 23.		Dr. H. H. Allan ..	45	0	0	..		
Dec. 23.		R. S. Allen	30	0	0	..		
Dec. 23.		Balance	706	8	7	..		
			£1,137	10	4	£1,137	10	4

By Balance £706 8s. 7d.

NEW ZEALAND INSTITUTE.—TRUST ACCOUNTS.

Carter Bequest.—Revenue Account for the Year ending 31st December, 1924.

Dr.	£ s. d.	*Cr.*	£ s. d.
To Interest invested in Post Office inscribed stock ..	298 19 11	By Balance	35 8 11
Balance	82 11 6	Interest on investments and Post Office Savings-bank	339 6 3
		Books sold	4 13 9
		Books exchanges for *Transactions*	2 2 6
	£381 11 5		£381 11 5
		By Balance	£82 11 6

Hector Memorial Fund for the Year ending 31st December, 1924.

Dr.	£ s. d.	*Cr.*	£ s. d.
To Balance	6 14 10	By Interest on investments ..	68 10 0
Prize, 1923	45 0 0	Interest, Post Office Savings-bank	0 11 2
Prize, 1924	45 0 0	Balance	27 13 8
	£96 14 10		£96 14 10
To Balance	£27 13 8		

Hamilton Memorial Fund for the Year ending 31st December, 1924.

Dr.	£ s. d.	*Cr.*	£ s. d.
To Balance	1 14 10	By Coupons	3 7 6
Amount overdrawn ..	0 3 11	Interest, Post Office Savings-bank	0 0 10
Balance	1 9 7		
	£3 8 4		£3 8 4
		By Balance	£1 9 7

Hutton Memorial Fund for the Year ending 31st December, 1924.

Dr.	£ s. d.	*Cr.*	£ s. d.
To Balance	80 2 7	By Balance	20 11 10
		Interest on investments ..	58 10 0
		Interest, Post Office Savings-bank	1 0 9
	£80 2 7		£80 2 7

Administration of Research Grants.—On the motion of Mr. Wright, seconded by Professor Worley, the following resolutions were carried:—

1. That the Board shall notify the affiliated societies of the funds available for research purposes, and invite applications at least three months prior to the latest date upon which such applications will be received by the Board.

2. That no allocation from the Research Grants Fund shall be made until after a certain specified date, upon which all applications for the period shall close.

3. That the date upon which the applications are to close shall be fixed by the Board.

4. That all applications for grants shall be considered as soon as possible after the closing-date by a Research Committee. The number of members and the personnel of the committee shall be determined by the Board.

5. That the Research Committee shall make its recommendation to the Board, and shall have power to make such inquiries and call for such reports, either confidentially or otherwise, as it may think fit, in order to guide its members in making recommendations.

On the motion of Dr. J. A. Thomson, it was resolved, That the Research Grants Committee consist of Dr. Chilton, Dr. C. C. Farr, Dr. Hilgendorf, Professor Speight, and Mr. A. M. Wright.

On the motion of Professor Easterfield, seconded by Dr. Malcolm, it was resolved, That the intimation of the acceptance or rejection of an application for a grant be made both to the society through which the application is made and also to the applicant himself.

Discussion on a letter from the Secretary of the Auckland Institute, dated 14th January, 1925, asking for a reconsideration of a decision of the Standing Committee regarding an Auckland application for research, was ruled out of order by the President, and the letter was referred to the Research Grants Committee.

Report of Research Grants Committee.

Dr. H. H. Allan, who, through the Philosophical Institute of Canterbury, in 1923 was granted £30 for an investigation of cocksfoot and rye-grass, reported on the 8th December that work had proceeded along the lines reported on previously (see vol. 55, p. 762). Valuable parcels of seeds have been received from the Welsh Plant-breeding Station and from the Royal Danish Agricultural Society. These seeds have been sown along with a further series of experimental plots. Dr. Allan proposes to contribute to the *New Zealand Journal of Agriculture* a series of articles bearing on points brought out in these preliminary trials. Unexpended portion of grant is £5.

Dr. H. H. Allan, who, through the Philosophical Institute of Canterbury, in August, 1924, was granted £30 for an investigation of Mount Egmont forests, reported on the 8th December that he had made arrangements to spend the month of January in the field making a preliminary examination of the forests.

The Artesian Wells Committee, which, through the Philosophical Institute of Canterbury, in 1921 was granted £100 for research into the sources of supply, constancy of flow, &c., of artesian wells of the Christchurch area, reported on the 2nd December that research on the fluctuations of the water-level in the Christchurch and neighbouring wells has been regularly prosecuted. No specially striking facts have recently come to light, but certainty has been reached on many important points which were previously only suppositions. A stage has now been reached at which the discovery of new facts by the method adopted is not commensurable with the labour involved in discovering them, and the research will be terminated. A full report will be presented for publication in the next volume of the *Transactions*. The expenditure amounted to £91 2s. 10d., and the balance has been relinquished.

Mr. G. Brittin, who, through the Philosophical Institute of Canterbury, in 1919 was granted £100 for a research in fruit-tree diseases, reported on the 9th December that the usual work of pruning and spraying had been carried out on the peach-trees under experiment with practically the same conclusions. Owing to the very wet weather brown-rot was very bad at the blossoming stage, but the application of an additional spray of 1-in-80 lime-sulphur stopped infection and saved a large proportion of the fruit. Investigations into the cause of falling fruit resulted in the conclusion that there was an insufficiency of nitrogen in the soil, and Mr. Brittin intends putting in a cover-crop of blue lupins in January, to be followed by lime when the crop is ploughed next spring. Mr. Brittin has been working in conjunction with Mr. Neil, of the Biological Department, in endeavouring to identify the disease of the peach-buds, so far with little result. The expenditure amounts to £6 18s.

Professor P. W. Burbidge, who, through the Auckland Institute, in 1921 was granted £100, and in 1923 an additional £25, for research on the intensity of long-wave signals, reported on the 4th December that during 1924 certain parts of the apparatus were reconstructed, and signals are now being well received. Arrangements are being made for regular signals from Lyons or Bordeaux, on which the actual measurements will be made. The work has been delayed during the session by the usual routine work, and, since it involves the taking of a continuous series of observations, will probably extend over the next two years. £104 3s. 4d. has been expended on apparatus.

Dr. K. M. Curtis, who, through the Nelson Institute, in 1920 was granted £100 for research in parasitic mycology, reported on the 14th December that she had carried out her research on twenty-two varieties of stone-fruits, including peach, apricot, nectarine, cherry, and plum, and it is evident that the current theory concerning the cause of resistance and susceptibility to the brown-rot fungus does not offer an adequate explanation for resistance in apricots, is even less adequate for peaches, and is quite inapplicable for cherries and nectarines. £99 15s. 4d. has been expended in books, and the balance refunded.

Mr. W. C. Davies, who, through the Nelson Institute, in 1921 was granted £50 for research in soil bacteria and protozoa, reported on the 16th December that the work on the bacteriology of typical soils of the Nelson district and on the soil micro-organisms of the tomato-houses of Nelson is being continued as opportunity offers, and should during the coming year reach a stage warranting publication. The whole of the grant has been expended.

Professor T. H. Easterfield, who, through the Nelson Institute, was in 1921 granted £200 for investigation in orchard chemistry, reported on the 15th December that the whole of the grant had been expended, and it covered only a small part of the cost of investigation. Great attention was paid to the problem of the cool storage of fruit, and the results of 1923 investigations have appeared in the *New Zealand Fruitgrower*, and have been issued separately by Messrs. McLelland and Tiller, who efficiently carried out the experiments. In December, 1923, the Nelson Freezing Company altered their methods of storing fruit in accordance with the indications of the experiments, with the result that not a single case of mature apples has been condemned. In 1922 and 1923, under the old system of storing, the losses were enormous.

Professor T. H. Easterfield, who, through the Wellington Philosophical Society, in 1919 was granted £250 for a research on New Zealand mineral oils, reported last year that the research was concluded, and the results published in the *Chemistry and Industry Review*. A *résumé* of the investigations has been published in the *New Zealand Journal of Science and Technology*, 1924, vol. 6, pp. 274–78.

Professor C. Coleridge Farr, who, through the Philosophical Institute of Canterbury, in 1919 was granted £100, and later an additional £90, for a research on the porosity of porcelain insulators, reported on the 12th December that a good deal of work has been done during the year, although no further call has been made on the grant. Many tests for porosity have been made on insulators submitted by the Public Works Department, and experiments in insulators which broke down in consequence of a crack developing in the top shell after the insulator had been erected in position proved the design to be faulty, with insufficient provision for expansion and contraction. An unexpanded balance of £55 11s. 6d. has been surrendered.

Professor Farr, who, through the Philosophical Institute of Canterbury, in 1921 was granted £15 for research on the physical properties of gas-free sulphur, reported on the 12th December that some progress had been made during the year. The installation of a liquid-air plant at the laboratory has taken place, and it will now be possible to obtain vacua of a much higher order than was hitherto the case. The balance in hand is £4 18s. 1d.

Professor Farr, who, through the Philosophical Institute of Canterbury, in 1923 was granted £30 for investigation of the goitre incidence in Christchurch, reported on the 17th December that his assistant, Mr. Rogers, M.Sc., has during the year vigorously carried out the work. Attention was concentrated upon the question of a possible correlation between the amount of radium-emanation in the drinking-waters of the different districts surrounding Christchurch and the amount of goitre in the schools. Some correlation was obtained in this respect as far as Christchurch and its environs were concerned, but it broke down absolutely at Timaru. The influence of iodine in the drinking-water was therefore considered, and analyses are still in progress. Expenditure amounting to £9 15s. 6d. has been incurred.

Professor Farr, who, through the Philosophical Institute of Canterbury, was granted £250 for an investigation of the occurrence of helium, reported on the 20th December that a beginning has been made with the investigation. Dr. Farr and his laboratory mechanic made a tour of examination round Taupo, collecting samples of gas from various springs. These samples were all hermetically sealed, and will be examined early in the year. Two small tins of gas were collected at the Karipiti blowhole, and were despatched immediately to Mr. Rogers at Christchurch, who examined them for radium-emanation. This examination confirmed the interesting result previously obtained by Dr. Marsden and Mr. Rogers, of the high radium-emanation content of the gas emitted from the hole. The high radium-emanation content seems therefore fairly well established, as the confirmation of the previous result was obtained on entirely different samples with entirely different apparatus and with another radium

standard. It is an interesting and perhaps an important result. Expenditure amounting to £56 4s. 8d. was incurred.

Mr. H. J. Finlay, who, through the Otago Institute, in 1923 was granted £10 to enable him to purchase certain books on palaeontology not procurable in New Zealand, reported on the 4th December that these books had now come to hand from Paris.

Mr. H. J. Finlay, who, through the Otago Institute, was in 1923 granted £100 for research on Tertiary Mollusca, reported on the 4th December that he is at work on various papers to be published in the *Transactions*. Collections of specimens have been made in Southland and Oamaru, and a great deal of work in sorting out and classifying, describing, &c., has been necessary. Expenditure amounting to £36 3s. 10d. has been incurred.

Mr. F. W. Foster, who in 1923 was granted £25 for the purpose of collating the notes and manuscript of the late Sir David Hutchins, reported on the 15th December that owing to his having to spend the greater part of the year in the field he had been unable to make rapid progress. The section on native forests and trees has been completed, and a start made on the exotic-trees portion. Mr. Foster is making a special effort to complete the work by May next.

Mr. H. Hamilton, who, through the Wellington Philosophical Society, in 1923 was granted £30 for research on the cave fauna of New Zealand, reported on the 13th January that the materials collected on his visit to the Waitomo Caves at Easter are being examined by specialists, and further material has been forwarded by the manager of the hostel at Waitomo. Expenditure so far has been £6.

Dr. J. K. H. Inglis, who, through the Otago Institute, in 1923 was granted £25 for research on the essential oils of the native plants, reported on the 10th December that the grant had been expended in apparatus specially designed, and investigation of the essential oils from *Dacrydium cupressinum* had been the subject of a preliminary paper by Messrs. McDowall and Finlay. *Leptospermum scoparium* investigation is not yet complete, and *Myoporum laetum* investigation is being continued by Mr. McDowall in England. A ton of ngaio-leaves has been put through the apparatus. Further work will be carried out in 1925.

Professor R. Jack, who, through the Otago Institute, in 1917 was granted £25 for investigation of the electric charge on rain, reported on the 4th December that the grant was expended in purchasing a cathode-ray oscillograph tube. During the session this apparatus has been employed in the investigation of the nature of the potentials, phases, amount of modulation, &c., in wireless circuits. The results have been embodied in a thesis for the degree of M.Sc., and an 1851 Exhibition Research Scholarship.

Dr. J. Malcolm, who, through the Otago Institute, in 1919 was granted £250, and later on £175, for a research on the food values of New Zealand fish, reported on the 16th December that investigations had been commenced on the insulin obtainable from groper and the large fish, but owing to difficulty in obtaining sufficient material the work was abandoned. Observations were made on the fat of the red cod under two different feeding-conditions, and a paper on the subject is in preparation for publication in the *Transactions*. Preliminary work on the vitamin-A content of mutton-bird oil and fish-oils was undertaken, and the evidence so far obtained shows that mutton-bird oil is one of the richest known natural sources of vitamin A.

Dr. J. Malcolm, who, through the Otago Institute, in 1918 was granted £30 for research on New Zealand plant products, reported on the 16th December that work had been carried on specially in connection with the action of pukateine hydrochloride on the heart. The unexpended balance is £10.

Dr. E. Marsden, who, through the Wellington Philosophical Society, during the year was granted £60 for a seismological research, reports that he has been unable to undertake research work until towards the close of the year.

Mr. E. K. Lomas, who, through the Wellington Philosophical Society, was granted in 1923 £25 for a research on the intelligence of school-children, reported on the 14th January that he had restricted himself to children in the Fifth and Sixth Standards of the schools in Wellington, and he has almost finished the preliminary work of examination. The detailed marking of about a thousand papers takes considerable time, and this work is only half-finished. Mr. Lomas trusts to be able to furnish a full and complete account of the whole investigation within three months.

Mr. R. Speight, who, through the Philosophical Institute of Canterbury, in 1919 was granted £225 for a geological survey of the Malvern Hills, reported on the 10th December that field-work had been continued in the area as occasion offered. Most of the work had reference to the circumstances governing the occurrence of clays and sands, notably the former. Samples were collected and transmitted to Mr. Page to deal with, and a detailed report has been submitted by Mr. Page. The general result of the field-work is to indicate that while the total volume of the clays is very great,

and some samples are of moderately high grade, large deposits of high-grade clay of uniform character are not likely to be met with. The deposits are essentially patchy, though one or two are perhaps promising. The report on the whole district should be available during the coming year. Expenses for the year amounted to £9 3s. 6d.

Messrs. Wild and Tankersley, who, through the Philosophical Institute of Canterbury, were in 1923 granted £25 for soil-survey in the Manawatu district, reported on the 15th January that early in the year Professor Speight assisted in working out the geological structure of the country under consideration. Some results have been published in a paper on the geology of the district in the November issue of the *Journal of Science and Technology*. During the year further observations of the soils of the district were made, samples collected, and some analytical work was done. Field experiment work (*a*) on the value of potash, and (*b*) on the top-dressing of grassland, has been carried on with the help of the staff in the Agricultural High School, and results have been published in Bulletins Nos. 2 and 3 of the school. Expenditure has amounted to £4 2s.

Professor F. P. Worley, who, through the Auckland Institute, in 1923 was granted £25 for a research on the chemistry of the essential oils of New Zealand flora, reported on the 22nd December that progress had been delayed for want of apparatus too costly to obtain from the grant, but this has now been obtained from other means. The investigation of the essential oil of one shrub is nearly completed, and will be ready for publication early next year. The balance of £15 will be expended during the summer in collecting fresh material for further investigation.

Mr. A. M. Wright, who, through the Philosophical Institute of Canterbury, in 1921 was granted £75 for research in the vitamin content of commercial meat products, reported on the 16th December that the work during the year was confined to a further examination of various modifications of the yeast cultural method for the determination of vitamin B in the cold-water extract from fresh and frozen beef. The results obtained indicate that the cold-water extracts from both the fresh and frozen materials contain some substance or substances which exert an influence upon the development and growth of yeast, but it is not possible as yet to state whether the results noted are due to the presence of vitamin B or to other substances. No expenditure has been incurred during the year.

Miss M. Mestayer reported that the balance of the Hutton grant of £10 has been expended in drawings for a paper she has written on New Zealand Amphineura.

Fellowship Election.—The election for two Fellowships was then proceeded with, and resulted in the election of Professor J. Macmillan Brown, Chancellor of the New Zealand University, and Dr. P. H. Buck (Te Rangi Hiroa), of the Health Department, Auckland.

It was resolved that the number of Fellows to be elected in 1925 be two.

Hector Award for 1925.—The recommendation of the Hector Award Committee, Professors Easterfield and Robertson, was then received by the President in a sealed envelope, as follows:—

The Hector Award Committee has had some difficulty in deciding between the qualifications of the New Zealand chemists eligible for the Hector Prize and Medal. They are, however, of the opinion that the award should be made to Mr. B. C. Aston, F.I.C., F.N.Z.Inst., Hon. Secretary of the New Zealand Institute and Chief Chemist in the Department of Agriculture, for his researches on the chemistry of bush sickness and of the New Zealand flora.

THOMAS H. EASTERFIELD,
Chairman, Hector Award Committee.

The recommendation was adopted.

Hector Prize Fund.—Report from Hon. Treasurer:—

The maximum amount of the prize is limited by the annual income derived from the investments of the Capital Fund: no part of the capital can be used for such purpose. The Board of Governors shall award any amount it may deem advisable for a prize up to the above-mentioned limit. In other words, the prize shall be to the value of any sum from one farthing to the maximum limit. No part of the revenue, except for administration expenses, can be applied to any other purpose than an annual prize.

The report was received. It was resolved that the amount of the Hector Prize for the next two years be £45.

Election of Honorary Member. — An election for one vacancy in the honorary members roll was then taken, and the Honorary Returning Officer (Professor Segar) later announced that Dr. A. C. Haddon, F.R.S., had been elected.

Vacancies in Honorary Membership.—It was announced that Dr. Otto Klotz, an honorary member, had died, and a vacancy was thus created to be filled at next annual meeting.

Catalogue of New Zealand Fishes.—On the motion of the Hon. G. M. Thomson, seconded by Dr. Chilton, it was resolved, That, in view of the recent action of the Government in appointing a scientific expert to report on the fisheries of New Zealand, a step which this Institute hails with pleasure, the Institute requests the Government to take the necessary steps to have a catalogue of the fishes of this Dominion prepared by a qualified expert.

Science Congress, 1926.—The Hon. G. M. Thomson announced the arrangements made for holding the Science Congress in Dunedin in January, next.

Pan-Pacific Congress.—Correspondence with the Auckland Institute was read, and, on the motion of Professor Easterfield, seconded by Professor Segar, it was resolved, That the New Zealand Institute approves of the holding of a Pan-Pacific Science Congress in Auckland at an early date, and is prepared to send an invitation for the holding of this conference to the meeting to be held in Japan in 1926; that a joint deputation of the New Zealand Institute and the Auckland Institute wait on the Government at a suitable date with a view to obtaining a grant of £2,000.

Advisory Board of Astronomy and Seismology.—Correspondence from the Under-Secretary of Internal Affairs was read, and, on the motion of Dr. C. Coleridge Farr, seconded by the Hon. G. M. Thomson, it was resolved, That in the opinion of this Board it is very desirable that a Board, consisting partly of scientific men appointed by the Board and partly of nominees of the Government, be set up by the Government to act on a Board of advice for the geophysical services of the Dominion.

Standing Committee Meetings.—On the motion of Mr. Wright, seconded by Dr. Farr, it was resolved, That notification of all meetings of the Standing Committee shall be sent to every member of the Board in time to reach him at least forty-eight hours prior to the meeting; the notification calling the meeting shall contain a memorandum of the business which is to come before the meeting.

Notices of Motion.—The following notices of motion were negatived:—

1. That the Standing Committee consists of seven members, to be appointed at the annual meeting of the Board of Governors. Proposed by Dr. Chilton.

2. That the last portion of clause 25 of the Regulations for the Fellowship of the New Zealand Institute be amended so as to read, "for five consecutive years," instead of "for three years immediately preceding his election." Proposed by Dr. Malcolm, seconded by Dr. Marshall.

3. That the fund now known as the Endowment Fund (now amounting to £334) having no defined use, and therefore not likely to be supplemented

by donations or bequests, be in future known as the Building Fund, with the defined object of contributing towards the cost of a building for the Institute, a requirement approved at the last annual meeting (see at foot of p. 748, vol. 55, and p. 745, for definition of Endowment Fund). Proposed by Mr. Aston, seconded by Mr. Eliott.

4. That clause 25, Regulations governing the Fellowship of the New Zealand Institute, be amended to read as follows: "No person shall be elected as Fellow unless he is a British subject and had been a member of one of the incorporated societies for ten years immediately preceding his election." Proposed by Mr. G. V. Hudson, seconded by Mr. Hill.

Election of Officers.—The election of officers resulted in the following appointments: President, Dr. P. Marshall; Hon. Secretary, Mr. B. C. Aston; Hon. Treasurer, Mr. M. A. Eliott; Hon. Editor, Mr. J. C. Andersen; Hon. Auditor, Professor Sommerville; Hon. Librarian, Professor Sommerville; Hon. Returning Officer, Professor Segar; Managers, Trust Accounts, Messrs. B. C. Aston and M. A. Eliott.

Election of Committees.—The following committees for 1925 were appointed:—

Publications Committee: The Standing Committee, with the Hon. Editor.

Research Grants Committee: Drs. Chilton, Farr, Hilgendorf, Professor Speight, and Mr. A. M. Wright.

Library Committee: Professors Sommerville, Kirk, Cotton, and Dr. Thomson.

Hector Award Committee: Messrs. Elsdon Best, Professor Benham, and Dr. Thomson.

Date and Place of next Annual Meeting.—To be held in Wellington on Tuesday, 26th January, 1926.

Votes of Thanks.—A special vote of thanks was unanimously accorded to Miss Wood, Assistant Secretary, for her work during the year. Votes of thanks were passed to Victoria College for the use of the rooms; to the Press for its attendance at the meeting; to the honorary officers of the Institute for their work during the past year; to the Hon. the Minister and the Under-Secretary for Internal Affairs, for the allocation of a room in the Parliament Buildings for the stocks of Transactions; and to the President.

Travelling-expenses.—It was resolved, That the travelling-expenses of the Governors to the meeting be paid.

APPENDIX.

NEW ZEALAND INSTITUTE ACT, 1908.

1908, No. 130.

An Act to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

Be it enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

(a.) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(b.) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(c.) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognized by this Act.

(d.) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year:

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine:

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month o January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48.—The New Zealand Institute Act, 1903.

NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[*30th July, 1920.*

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words "one thousand pounds."

FROM THE FINANCE ACT, 1925, No. 51.

7. (1.) The Minister of Finance shall, without further authority than this section, pay to the Board of Governors of the New Zealand Institute the sum of one thousand five hundred pounds in each financial year, commencing with the year beginning on the first day of April, nineteen hundred and twenty-five, to be applied in or towards payment of the general expenses of the Institute.

(2.) This section is in substitution for section ten of the New Zealand Institute Act, 1908, and that section and the New Zealand Institute Amendment Act, 1920, are hereby repealed.

REGULATIONS.

The following are the regulations of the New Zealand Institute under the Act of 1903:—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

Publications.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

(*a.*) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

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* *New Zealand Gazette*, 14th July, 1904.

(*e*.) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f*.) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

10A. Vacancies in the list of honorary members shall be announced at each annual meeting of the Board of Governors, and such announcement be communicated as early as possible to each incorporated society, and each such society shall on or before the 1st December nominate one person for each vacancy as honorary member, and the election shall take place at the next annual meeting of the Board of Governors.

General Regulations.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

Regulations governing the Fellowship of the Institute.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows shall be nominated as provided for in Regulation 26 (*a*), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be elected as Fellow unless he is a British subject and has been a member of one of the incorporated societies for three years immediately preceding his election.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows:—

(*a*.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.

(*b.*) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.

(*c.*) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.

(*d.*) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.

(*e.*) The methods of selection in subclause (*b*) and of election in subclause (*d*) shall be determined by the Board of Governors.

(*f.*) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

26A. The consent of the candidate must be obtained in writing.

The information regarding each candidate shall be condensed to one foolscap sheet of typewritten matter.

When a candidate is proposed by more than one society it shall be sufficient to circulate to voters the information supplied by one society.

Subsection (*c*) shall be rescinded, and the following inserted :—

Method of Selection in Subclause (b) *and of Election in Subclause* (d)

Names of Candidates, in Alphabetical Order.	
Apple, Charles	
Brown, John	
Smith, James	

There are vacancies to be filled. Place a cross in the column marked X against the name of each candidate for whom you wish to vote. The vote will be invalid if—

(*a.*) More than the required number is voted for on the paper :

(*b.*) The voter signs the voting-paper :

(*c.*) The voting-paper is not returned on the date announced.

Amendment to Regulations.

Regulation 5 (*a*) of the regulations published in the *New Zealand Gazette* of the 14th July, 1904, is hereby amended to read :—

"(*a.*) The publications of the Institute shall consist of—

"(1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

"(2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute.*"

ADDITIONAL REGULATIONS.

The following additional regulations, made at various times by the Board of Governors under the New Zealand Institute Act, 1908, were adopted at a general meeting of the Board held on the 30th January, 1923, and published in the *New Zealand Gazette* of the 28th May, 1925:—

Board of Governors.

Members of the Board of Governors shall not hold any paid office under the Board.

General Regulations.

The President shall be *ex officio* a member of all committees.

The Hon. Editor shall be convener of the Publications Committee.

The seal of the old Institute bearing the date of establishment as 1867 shall be adopted as the seal of the New Zealand Institute reconstituted by the New Zealand Institute Act, 1903, and continued by the New Zealand Institute Act, 1908.

An abstract of all business transacted at each meeting of the Standing Committee shall be prepared and communicated to all members of the Board after each meeting.

The quorum of the Standing Committee meetings shall be four.

Endowment Fund.

A fund to be called an "Endowment Fund" shall be set up, the interest on which for any year may be spent for purposes of the Institute, but the capital may not be spent.

All interest accruing from moneys deposited in the Institute's General Account in the Post Office Savings-bank shall be credited to the Endowment Fund, unless otherwise allocated by the Board at the annual meeting at which the amount of the annual interest is reported.

Trust Accounts.

Trust-moneys — namely, the Carter, Hector, Hutton, and Hamilton Funds— shall, when deposited in the Post Office Savings-bank, be placed in separate accounts for each trust.

BOARD OF SCIENCE AND ART.

From the Science and Art Act, 1913, No. 22.

8. (1.) Three shall be a Board styled "The Board of Science and Art," consisting of—

The Minister of Internal Affairs:

The Director of the Dominion Museum:

The President of the New Zealand Institute:

Five persons to be appointed by the Governor-General in Council, each of whom shall hold office for three years from the date of his appointment.

(2.) The Board shall sit in the City of Wellington at such times and places as shall be appointed from time to time by the Minister.

(3.) Three of the members shall form a quorum.

(4.) At all meetings of the Board the Minister, if present, shall be the Chairman, and in his absence some member of the Board appointed by him in writing shall be Chairman.

(5.) The Chairman shall have a deliberate vote, and in all cases of equality of votes shall have a casting-vote.

(6.) *The President of the New Zealand Institute may appoint in writing a deputy, being a Governor of the New Zealand Institute, to attend and act at any meeting of the Board in his place: and such deputy, while so attending, shall be deemed to be a member of the Board.*

TONGARIRO NATIONAL PARK BOARD.

From the Tongariro National Park Act, 1922, No. 31.

5. (1.) The park shall be controlled and managed by a Board constituted as hereinafter provided.

(2.) The Board shall be a body corporate under the name of the Tongariro National Park Board, with perpetual succession and a common seal, and shall be capable of holding real and personal property and of doing and suffering all that bodies corporate may lawfully do or suffer.

(3.) The Board shall consist of the following persons:—

- (*a.*) The Minister of Lands:
- (*b.*) The paramount chief for the time being of the Ngatituwharetoa Tribe of the Native race if that chief is a lineal descendant of Te Heuheu Tukino, the donor of the Native land included in the area of the Tongariro National Park:
- (*c.*) The Mayors of the cities of Auckland and Wellington:
- (*d.*) The Warden of the Park:
- (*e.*) The Under-Secretary of the Department of Lands and Survey:
- (*f.*) The General Manager of the Department of Tourist and Health Resorts:
- (*g.*) The Secretary of the State Forest Service:
- (*h.*) *The President of the New Zealand Institute:*
- (*i.*) Not more than four persons to be appointed in that behalf by the Governor-General in Council.

8. (1.) The first ordinary meeting of the Board shall be held at such time and place as the Minister appoints, and subsequent ordinary meetings shall be held at such times and places as the Board appoints.

(2.) Special meetings of the Board may be called at any time by the Chairman, and he shall call one whenever any three members so request in writing.

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Declaration of Trust.

This deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s.), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

Resolutions of Board of Governors.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the *Transactions of the New Zealand Institute* the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette *of 28th May, 1925.*

That the fund known as the "Hutton Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

That until the Hutton Memorial Fund reaches the sum of £1,000 not less than 1 per cent. on the capital invested be added each year to the principal.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct earing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L S., F.R.S.—For researches on the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

1923. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst.—For researches in geology.

Grant from the Hutton Memorial Research Fund.

1919. Miss M. K. Mestayer—£10, for work on the New Zealand Mollusca.

1923. Professor P. Marshall, M.A., D.Sc., F.N.Z.Inst.—£40, for study of Upper Cretaceous ammonites of New Zealand.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part: Whereas by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal

and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid:

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and Prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette *of 28th May, 1925.*

That the fund known as the "Hector Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

AWARD OF THE HECTOR MEMORIAL RESEARCH FUND.

1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
1914. Elsdon Best—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—For researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.
1919. P. W. Robertson—For researches in chemistry.
1920. S. Percy Smith—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.
1922. C. Coleridge Farr, D.Sc.—For research in physical science, and more particularly work in connection with the magnetic survey of New Zealand.
1923. G. V. Hudson, F.E.S., F.N.Z.Inst.—For researches in New Zealand entomology.
1924. D. Petrie, M.A., F.N.Z.Inst.—For researches in New Zealand botany.
1925. B. C. Aston, F.I.C., F.N.Z.Inst.—For the investigation of New Zealand chemical problems.

HAMILTON MEMORIAL FUND.

1. The fund placed in the hands of the Board by the Wellington Philosophical Society shall be called the "Hamilton Memorial Fund" in memory of the late Augustus Hamilton, Esq. Such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The fund shall be vested in the Institute. The Board of Governors of the Institute shall have the control thereof, and shall invest the same in any securities proper for trust-moneys.

3. The memorial shall be a prize, to be called the "Hamilton Memorial Prize," the object of which shall be the encouragement of beginners in pure scientific research in New Zealand.

4. The prize shall be awarded at intervals of not less than three years by the Governors assembled in annual meeting, but in no case shall an award be made unless in the opinion of the Governors some contribution deserving the honour has been made. The first award shall be made at the annual meeting of the Governors in 1923.

5. The prize shall be awarded for original pure scientific research-work, carried out in New Zealand or in the Islands of the South Pacific Ocean, which has been published within the five years preceding the first day of July prior to the annual meeting at which the award is made. Such publication may consist of one or more papers, and shall include the first investigation published by the author. No candidate shall be eligible for the prize who prior to such period of five years has published the result of any scientific investigation.

6. The prize shall consist of money. Until the principal of the fund amounts to £100, one-half of the interest shall be added annually to the principal and the other half shall be applied in payment of the prize. So soon as the said principal amounts to £100 the whole of the interest thereon shall be applied in payment of the prize, in each case after the payment of all expenses necessarily incurred by the Governors in the investment and administration of the said fund and award of the said prize.

7. A candidate for the prize shall send to the Hon. Secretary of the New Zealand Institute, on or before the 30th day of June preceding the date of the annual meeting at which the award is to be made, an intimation of his candidature, together with at least two copies of each publication on which his application is based.

8. Whenever possible the prize shall be presented in some public manner.

REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.*

ALL grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions :—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless

* In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports), containing (*a*) a brief statement showing the results arrived at or the stage which the inquiry has reached; (*b*) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (*c*) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession; and (*d*) references to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

Additional Regulations adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

8. Grants shall be given preferentially to investigations which appear to have an economic bearing; purely scientific investigations to be by no means excluded. When the research is one that leads to a direct economic advance the Government shall reserve to itself the right of patenting the discovery and of rewarding the discoverer, but it is to be understood that grants from the research-grant vote are not in the nature of a reward or a prize, but for out-of-pocket expenses incurred by the research worker,

including salary or endowment of assistant, but not salary for the grantee himself. Plants, books, apparatus, chemicals, &c., purchased for applicants are to remain the property of the Institute, and eventually to form a loan collection of apparatus in the manner now practised by the Royal Society of London.

First method of initiating researches: Applications shall be invited for grants in aid of research to be specified by applicants.

Second method of initiating researches: The Governors of the Institute shall suggest from time to time subjects the investigation of which is desirable, and ask capable investigators to undertake such researches, the Institute paying for apparatus, material, and working-expenses, including assistance.

9. All applications for grants shall come through some incorporated society.

10. In the case of a refusal to recommend a grant, the Standing Committee shall not give any reasons for its refusal, unless such reason is stated in the minutes of the Standing Committee's meeting.

Research Grants made for the Period ending December, 1924.

Through the Wellington Philosophical Society:—

Dr. Marsden, £60 for further seismological research.
Mr. W. J. Phillipps, £30 for research on the life-histories of N.Z. fishes.

Through the Philosophical Institute of Canterbury:—

Mr. R. M. Laing, £100 for research on N.Z. algae.
Professor C. C. Farr, £250 for research on helium in New Zealand.
Dr. H. H. Allan, £50 for forestry research on Mount Egmont.
Captain. L. M. Isitt, £100 for upper-air research.

Through the Otago Institute:—

Dr. J. K. Inglis, £20 for investigation on the essential oils of N.Z. plants.
Mr. F. McDowall, £60 for investigation of ngaio-oil.
Mr. R. S. Allan, £40 for research on Chatham Island rocks.

Through the Nelson Institute:—

Mr. F. V. Knapp, £25 for collecting Maori artifacts.

THE CARTER BEQUEST.

Extracts from the Will of Charles Rooking Carter.

This is the last will and testament of me, Charles Rooking Carter, of Wellington, in the Colony of New Zealand, gentleman.

I revoke all wills and testamentary dispositions heretofore made by me, and declare this to be my last will and testament.

* * * * * * *

I give to the Colonial Museum in Wellington the large framed photographs of the members of the General Assembly in the House of

Representatives in the year 1860, and the framed pencil sketch of the old House of Commons, and the framed invitation-card to the Lord Mayor's dinner.

As regards the following books, of which I am the author, and which are now stored in three boxes—namely, (1) "The Life and Recollections of a New Zealand Colonist," (2) "A Historical Sketch of New Zealand Loans," and (3) "Round the World Leisurely"—I direct that my executor shall retain possession of the same for a period of seven years, commencing from the date of my death, and that at the end of such period my executor shall place the same in the hands of Messrs. Whitcombe and Tombs (Limited) or some other capable and responsible booksellers in the City of Wellington, for sale, and so that the same shall be sold at such a price as will yield to my estate not less than six shillings per volume in respect of the first-named and second-named, and two shillings and sixpence in respect of the last-named works; and I further authorize my executor to sell and dispose of the copyright or right to reprint such works; and I direct that the moneys to be derived from the sale of such works and the privileges connected therewith shall be added to the sum provided for the purchase of a telescope as hereinafter mentioned.

I direct my executor to subscribe the sum of fifty pounds towards the erection of a suitable brick room in which to house the priceless collection of books on New Zealand some time since given by me to the Colonial Museum and the New Zealand Institute.

I give and devise unto the Public Trustee appointed under and in pursuance of an Act of the General Assembly of New Zealand intituled the Public Trust Office Act, 1894 (hereinafter called "my trustee"), all the rest, residue, and remainder of my property whatsoever and wheresoever situate, both real and personal, and whether in possession, reversion, expectancy, or remainder, upon trust, as to my freehold property at East Taratahi, containing by admeasurement two thousand one hundred and seventy-two acres, and being and comprising the whole of the land included in certificate of title, volume 51, folio 79, of the books of the District Land Registrar for the Registration District of Wellington, (save and except such part of the said land, being portion of the section numbered 117 in the Taratahi Plain Block, as is hereinafter devised to my trustee for the purposes hereinafter appearing), and direct that my trustee shall stand possessed of the same lands upon trust, to let and manage the same, and to pay and apply the rents and annual income in manner following, namely:—

And as to all the residue and remainder (if any) of the said net proceeds of the sale, conversion, and getting-in of my estate as aforesaid, my trustee shall transfer the same to the Governors for the time being of the New Zealand Institute at Wellington, to form the nucleus of a fund for the erection in or near Wellington aforesaid, and the endowment of

a Professor and staff, of an Astronomic Observatory fitted with telescope and other suitable instruments for the public use and benefit of the colony, and in the hope that such fund may be augmented by gifts from private donors, and that the Observatory may be subsidized by the Colonial Government; and without imposing any duty or obligation in regard thereto I would indicate my wish that the telescope may be obtained from the factory of Sir H. Grubb, in Dublin, Ireland.

Resolution regarding Investment of Funds (see Clause 4 above), adopted by Board on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

That the fund known as the "Carter Bequest," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

NEW ZEALAND INSTITUTE, 1925.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1923); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1923); Dr. Charles Chilton, F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1924); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (reappointed December, 1924).

ELECTED BY AFFILIATED SOCIETIES, 1923.

Wellington Philosophical Society ...	Mr. G. V. Hudson, F.E.S., F.N.Z.Inst. Mr. P. G. Morgan, M.A., F.G.S., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury	Professor C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst. Mr. A. M. Wright, A.I.C., F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Professor J. Malcolm, M.D.
Hawke's Bay Philosophical Institute	Mr. H. Hill, B.A., F.G.S.
Nelson Institute	Professor T. H. Easterfield, M.A., Ph.D., F.I.C., F.N.Z.Inst.
Manawatu Philosophical Society ...	Mr. M. A. Eliott.
Wanganui Philosophical Society ...	P. Marshall, M.A., D.Sc., F.G.S., F.G.S., F.N.Z.Inst.

OFFICERS FOR THE YEAR 1925.

PRESIDENT: Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.

HON. TREASURER: Mr. M. A. Eliott.

HON. EDITOR: Mr. Johannes C. Andersen, F.N.Z.Inst.

HON. LIBRARIAN: Professor D. M. Y. Sommerville, M.A., D.Sc., F.R.S.E., F.N.Z.Inst.

HON. RETURNING OFFICER: Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst.

HON. AUDITOR: Professor D. M. Y. Sommerville, M.A., D.Sc., F.R.S.E., F.N.Z.Inst.

HON. SECRETARY: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.

(Box 40, Post-office, Wellington.)

AFFILIATED SOCIETIES, 1924-25

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	Mr. W. J. Phillipps, Dominion Museum	10th June, 1868.
Auckland Institute ..	Mr. G. Archey, Auckland Museum and Institute, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	Mr. G. Jobberns, Training College, Christchurch	22nd October, 1868.
Otago Institute	Rev. Dr. Holloway, Otago University, Dunedin	18th October, 1869.
Hawke's Bay Philosophical Institute	Mr. C. F. H. Pollock, P.O. Box 301, Napier	31st March, 1875.
Nelson Institute	Mrs. Margaret Graham, Nelson	20th December, 1883.
Manawatu Philosophical Society	Mr. C. T. Salmon, P.O. Box 293, Palmerston North	6th January, 1905.

FORMER MANAGER AND EDITOR.

[UNDER THE NEW ZEALAND INSTITUTE ACT, 1867.]

1867–1903.—Hector, Sir James, M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

1903–4.—Hutton, Captain Frederick Wollaston, F.R.S.

1905–6.—Hector, Sir James, M.D. K.C.M.G., F.R.S.

1907–8.—Thomson, George Malcolm, F.L.S.

1909–10.—Hamilton, A.

1911–12.—Cheeseman, T. F., F.L.S., F.Z.S.

1913–14.—Chilton, C., M.A., D.Sc., LL.D., F.L.S , C.M.Z.S.

1915.—Petrie, D., M.A., Ph.D.

1916–17.—Benham, W. B., M.A., D.Sc., F.Z.S., F.R.S.

1918–19.—Cockayne, L., Ph.D., F.R.S., F.L.S., F.N.Z.Inst.

1920–21.—Easterfield, T. H., M.A., Ph.D., F.N.Z.Inst.

1922–23.—Kirk, H. B., M.A., F.N.Z.Inst.

HONORARY MEMBERS.

	Elected
Bateson, Professor W., F.R.S., Merton, Surrey, England	1915
Beddard, F. E., D.Sc., F.R.S., Zoological Society, London	1906
Bragg, Professor W. H., F.R.S., University of London	1923
Chree, Charles, M.A., D.Sc., LL.D., F.R.S., Kew Observatory, London ..	1924
David, Professor T. Edgeworth, F.R.S., C.M.G., Sydney University	1904
Davis, Professor W. Morris, Harvard University, Cambridge, Mass., U.S.A. ..	1913
Dendy, Dr. A., F.R.S., King's College, University of London, England ..	1907
Diels, Professor L., Ph.D., University of Marburg	1907
Einstein, Professor Albert, University of Berlin, Germany	1924
Fraser, Sir J. G., D.C.L., No. 1 Brick Court, Temple, London, E.C. 4	1920
Goebel, Professor Dr. Carl von, University of Munich	1901
Goodale, Professor G. L., M.D., LL.D., Harvard University, Cambridge, Mass., U.S.A.	1891
Gregory, Professor J. W., D.Sc., F.R.S., F.G.S., University, Glasgow	1920
Haddon, Dr. A. C., F.R.S., 3 Cranmer Road, Cambridge	1925
Hall, Sir A. D., M.A., K.C.B., F.R.S., Ministry of Agriculture, London ..	1920
Haswell, Professor W. A., F.R.S, Mimihau, Woollahra Point, Sydney ..	1914
Hedley, Charles, F.L.S., Australian Museum, Sydney	1924
Hemsley, Dr. W. Botting, F.R.S., Kew Lodge, St. Peter's Road, Broadstairs, Kent, England	1913
Klotz, Professor Otto J., 437 Albert Street, Ottawa, Canada	1903
Liversidge, Professor A., M.A., F.R.S., Fieldhead, Coombe Warren, Kingston Hill, England	1890
Massart, Professor Jean, University of Brussels, Belgium	1916
Mawson, Sir Douglas, B.E., D.Sc., The University, Box 498, Adelaide	1920
Mellor, Joseph William, D.Sc. (N.Z.), Sandon House, Regent Street, Stoke-on-Trent, England	1919
Meyrick, E., B.A., F.R.S., Marlborough College, England	1907
Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden	1890
Rutherford, Professor Sir E., D.Sc., F.R.S., F.N.Z.Inst., Nobel Laureate, Cambridge, England	1904
Sars, Professor G. O., University of Christiania, Norway	1902
Stebbing, Rev. T. R. R., F.R.S., Tunbridge Wells, England	1907
Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Witcombe, Gloucester, England	1894
Woods, Henry, M.A., F.R.S., F.G.S., University, Cambridge	1920

FORMER HONORARY MEMBERS.

	Elected
Agardh, Dr. J. G.	1900
Agassiz, Professor Louis	1870
Arber, E. A. Newell, M.A., Sc.D., F.G.S., F.L.S.	1914
Avebury, Lord, P.C., F.R.S. ..	1900
Baird, Professor Spencer F. ..	1877
Balfour, Professor I. Bayley, F.R.S.	1914
Beneden, Professor J. P. van ..	1888
Berggren, Dr. S.	1876
Bowen, Sir George Ferguson, G.C.M.G.	1878
Brady, G. S., D.Sc., F.R.S. ..	1906
Bruce, Dr. W. S.	1910
Carpenter, Dr. W. B., C.B., F.R.S.	1883
Clarke, Rev. W. B., M.A., F.R.S. ..	1876
Codrington, Rev. R. H., D.D. ..	1894
Darwin, Charles, M.A., F.R.S. ..	1871
Darwin, Sir George, F.R.S. ..	1909
Davis, J. W., F.G.S., F.L.S. ..	1891
Drury, Captain Byron, R.N. ..	1870
Ellery, Robert L. J., F.R.S. ..	1883
Etheridge, Professor R., F.R.S. ..	1876
Ettingshausen, Baron von ..	1888
Eve, H. W., M.A.	1901
Filhol, Dr. H.	1875
Finsch, Professor Otto, Ph.D. ..	1870
Flower, Professor W. H., F.R.S. ..	1870
Garrod, Professor A. H., F.R.S. ..	1878
Gray, J. E., Ph.D., F.R.S. ..	1871
Gray, Professor Asa	1885
Grey, Sir George, K.C.B. ..	1872
Günther, A., M.D., M.A., Ph.D., F.R.S.	1873
Hochstetter, Dr. Ferdinand von ..	1870
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M.	1870
Howes, G. B., LL.D., F.R.S.	1901
Huxley, Thomas H., LL.D., F.R.S.	1872
Langley, S. P.	1896
Lindsay, W. Lauder, M.D., F.R.S.E.	1871
Lydekker, Richard, F.R.S. ..	1896
Lyell, Sir Charles, Bart., D.C.L., F.R.S.	1873
McCoy, Professor Sir F., K.C.M.G., D.Sc., F.R.S.	1888
McLachlan, Robert, F.L.S. ..	1874
Massee, George, F.L.S., F.R.M.S.	1900
Milne, J., F.R.S.	1906
Mitten, William, F.R.S.	1895
The Most Noble the Marquis of Normanby, G.C.M.G.	1880
Mueller, Ferdinand von, M.D., F.R.S., C.M.G.	1870
Müller, Professor Max, F.R.S. ..	1878
Newton, Alfred, F.R.S.	1874
Owen, Professor Richard, F.R.S. ..	1870
Pickard-Cambridge, Rev. O., M.A., F.R.S., C.M.Z.S.	1873
Richards, Rear-Admiral G. H. ..	1870
Riley, Professor C. V.	1890
Rolleston, Professor G., M.D., F.R.S.	1875
Sclater, P. L., M.A., Ph.D., F.R.S.	1875
Sharp, Dr. D.	1877
Sharp, Richard Bowdler, M.A., F.R.S.	1885
Stokes, Vice-Admiral J. L. ..	1872
Tenison-Woods, Rev. J. E., F.L.S.	1878
Thomson, Professor Wyville, F.R.S.	1874
Thomson, Sir William, F.R.S. ..	1883
Wallace, Sir A. R., F.R.S., O.M. ..	1885
Weld, Frederick A., C.M.G. ..	1877

FELLOWS OF THE NEW ZEALAND INSTITUTE.

Original Fellows.

(See *New Zealand Gazette*, 20th November, 1919.)

Aston, Bernard Cracroft, F.I.C., F.C.S.
*‡Benham, Professor William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
†Best, Elsdon.
*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S. §
*†Chilton, Professor Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
*†‡Cockayne, Leonard, Ph.D., F.R.S., F.L.S.
†Easterfield, Professor Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.
Farr, Professor Clinton Coleridge, D.Sc., F.P.S.L., Assoc.M.Inst.C.E.
Hogben, George, C.M.G., M.A., F.G.S. §
Hudson, George Vernon, F.E.S.
Kirk, Professor Harry Borrer, M.A.
†‡Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
*Petrie, Donald, M.A., Ph.D.
†Rutherford, Sir Ernest, Kt., F.R.S., D.Sc., Ph.D., LL.D.
Segar, Professor Hugh William, M.A.
Smith, Stephenson Percy, F.R.G.S. §
Speight, Robert, M.A., M.Sc., F.G.S.
Thomas, Professor Algernon Phillips Withiel, M.A., F.L.S.
*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S

Fellows elected, 1921.

Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.
Hilgendorf, Frederick William, B.A., D.Sc.
Holloway, Rev. John Ernest, L.Th., D.Sc.
Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

Fellows elected, 1922.

Laing, Robert Malcolm, M.A., B.Sc.
Marsden, Ernest, D.Sc., F.R.A.S.
Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.
Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E.

Fellows elected, 1923.

Williams, Ven. Archdeacon Herbert William, M.A.
Andersen, Johannes Carl.

Fellows elected, 1924.

Smith, William Herbert Guthrie.
Tillyard, Robin John, M.A., D.Sc., Sc.D., F.L.S., F.E.S.

Fellows elected, 1925.

Brown, Professor J. Macmillan, M.A., LL.D.
Te Rangi Hiroa (P. H. Buck), M.D., Ch.B. (N.Z.).

* Past President. † Hector Medallist. ‡ Hutton Medallist. § Deceased.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

[* Life Members.]

Ackland, E. W., P.O. Box 928, Wellington.
Adams, C. E., D.Sc., A.I.A. (London), F.R.A.S., Hector Observatory, Wellington.
Adkin, G. L., Queen Street, Levin.
Andersen, Johannes C., F.N.Z.Inst., Alexander Turnbull Library, Bowen Street, Wellington.
Andrew, R. L., Dominion Laboratory, Wellington.
Aston, B. C., F.I.C., F.C.S., F.N.Z.Inst., Dominion Laboratory, Wellington.
Atkinson, E. H., 71 Fairlie Terrace, Kelburn.
Baillie, H., Public Library, Wellington.
Baldwin, E. S., 215 Lambton Quay, Wellington.
Baldwin, H., Inspector of Machinery, Wellington
Balneavis, H. R. H., Parliament Buildings, Wellington.
Barwell, J. S., Chatham Islands.
Bates, D. C., Meteorological Office, Wellington.
Bayne, J. A. C., Inspecting Engineer, Mines Department.
Beckett, Peter, Paraparaumu.
Bell, E. D., Panama Street, Wellington.
Bell, Sir Francis, Panama Street, Wellington.
Bennett, Francis, Queen Alexandra Street, Khandallah.
Berry, C. G. G., Railway Buildings, Wellington.
Best, Elsdon, F.N.Z.Inst., Dominion Museum, Wellington.
Blair, David K., M.I.Mech.E., 9 Grey Street, Wellington
Bradshaw, G. B., Box 863, Wellington.
Brandon, A de B., B.A., Featherston Street, Wellington.
Brent, H. C., Laboratory, G.P.O., Wellington.
Brodrick, T. N., care of F. J. Slade-Gully, Lichfield, via Putaruru.
Bruce, E., 71 Fairlie Terrace, Wellington.
Buick, T. Lindsay, Press Association, Box 1514, Wellington.
Cachemaille, E. D., care of Harbour Board, Wellington.
Cameron, Dr. R. A., 148 Willis Street, Wellington.
Chamberlin, T. Chamberlin, Crescent Road, Khandallah.
Cobeldick, W., F.R.G.S., Tourist Department, Rotorua.
Cockayne, A. H., Agriculture Department, Wellington.
Cockayne, L., Ph.D., F.L.S., F.R.S., F.N.Z.Inst., Ngaio, Wellington.
Cockroft, T., 111 Owen Street, Wellington.
Cotton, C. A., D.Sc., F.G.S., F.N.Z.Inst., Victoria University College, Wellington.
Coventry, Mrs. H., 22 Disley Street, Kelburn.
Crawford, A. D., Box 126, G.P.O., Wellington.
Cromb, J. B., Harbour Board, Wellington.
Cull, J. E. L., B.Sc. in Eng. (Mech.), Public Works Department, Wellington.
Cumming, E., Land and Income Tax Department, Wellington.
Dalrymple, K. W., Parewanui, Bull's.
Darling, J., Kelburn.
Davies, V. C., Westown, New Plymouth.
Dixon, Miss A. M., Mount Cook Girls' School, Buckle Street, Wellington.
Donovan, W., M.Sc., Dominion Laboratory, Wellington.
Dougall, Archibald, 9 Claremont Grove, Wellington.
Dyer, Miss M., Education Department, Wellington.
Dymock, E. R., F.I.A.N.Z., A.I.A.V., Box 193, Wellington.
Earnshaw, W., 4 Watson Street, Wellington.
Ellis, E. MacIntosh, Director, Forestry Department, Wellington.
Evans, Professor W. P., Kensington Street, Wellington.
Ferguson, William, M.A., M.Inst.C.E., M.I.Mech.E., Silverstream, Wellington.
Ferrar, H. T., M.A., F.G.S., Geological Survey Department, 156 The Terrace.*
Fletcher, Rev. H. J., The Manse, Taupo.
Florance, Professor, Victoria College, Wellington.
Forrester, J. H., Customs Department, Wellington.
Freeman, C. J., 95 Webb Street, Wellington.*
Frengley, Dr., Messines Road, Karori.
Frost, C. A., care of Richardson, McCabe, and Co., Wellington.
Furkert, F. W., Assoc.M.Inst.C.E., Public Works Department, Wellington.
Garrow, Professor J. M. E., B.A., LL.B., Victoria University College, Wellington.*
Gibbs, A. E., M.I.E.E., Assistant Telegraph Engineer, G.P.O., Wellington.
Gibbs, Dr. H. E., 240 Willis Street, Wellington.
Gifford, A. C., M.A., F.R.A.S., 6 Shannon Street, Wellington.*

Gilbert, Rev. Father T. A., St. Patrick's College, Wellington.
Gillies, R., Marine Superintendent, U.S.S. Company (Limited), Wellington.
Good, F. W., Main-superintendent, Electric Light Department, Harris Street, Wellington.
Grange, L. I., 38 The Terrace, Wellington.
Gray, W., Mauriceville.
Greenshields, F. S., 9 Glen Road, Kelburn.
Grimmett, R. E. R., Agricultural Laboratory, Wellington.
Hamilton, H., A.O.S.M., Dominion Museum, Wellington.
Hansford, George D., Box 1025, Wellington.
Hardcastle, H., *Evening Post*, Wellington.
Hastie, Miss J. A., care of Street and Co., 30 Cornhill, London, E.C.*
Hector, C. Monro, M.D., B.Sc., F.R.A.S., Hobson Street, Wellington.
Helyer, Miss E., 13 Tonks Grove, Wellington.
Henderson, J., M.A., D.Sc., B.Sc. in Eng. (Metall.), Geological Survey Department, Wellington.
Hislop, J., Internal Affairs Department, Wellington.
Hodson, W. H., 40 Pirie Street, Wellington.
Holmes, R. W., M.Inst.C.E., Burnell Avenue, Wellington.
Hooper, Captain G. S., Marine Department, Wellington.
Hooper, R. H., 6 St. John Street, Wellington.
Hudson, G. V., F.E.S., F.N.Z.Inst., Hill View, Karori.
Hurley, J. A., Bacteriological Laboratory, Newtown.
Jack, J. W., 170 Featherston Street, Wellington.
Jacobson, N. R., Training College, Kelburn.
Jenkinson, S. H., Railway Department, Wellington.
Jones, A. Morris, 47 Upland Road, Kelburn.
Jones, J. A., Assistant Chief Engineer, N.Z. Railways, Wellington.
Joseph, Joseph, P.O. Box 443, Wellington.
Joyce, Miss, Training College, Kelburn.
Kerr, W. J., National Bank, Grey Street, Wellington.
Kirk, Professor H. B., M.A., F.N.Z.Inst., Victoria University College, Wellington.
Kissell, F. T. M., Public Works Department, Wellington.
Knight, C. Prendergast, 126 Bolton Street, Wellington.
La Trobe, W. S., M.A., Hamilton Road, Karori.
Lauchlan, G., Electrical Engineer, Harris Street, Wellington.
Lawrence, G. A., Johnsonville.
Leighton, F. T., Dominion Laboratory.
Levi, P., M.A., care of Wilford and Levi, 15 Stout Street, Wellington.
Levy, E. Bruce, 71 Fairlie Terrace, Kelburn.
Lomas, E. K., M.A., M.Sc., Training College, Wellington.
Lomax, Major H. A., 288 Somme Parade, Aramoho, Wanganui.
Longhurst, W. T. A., Norway Street, Kelburn.
Loy, Miss E., Training College, Kelburn.
Luke, Sir John P., C.M.G., M.P., "Pendennis," Burnell Avenue, Wellington.
McCalman, L. H., Telegraph-office, Gore.
McCulloch, A. R., Australian Museum, Sydney.
Macdonald, J., Assistant General Manager, Railway Department, Wellington.
McDonald, J., Dominion Museum, Wellington.
Macfarlane, C. F. C., Dominion Farmers' Buildings, Wellington.
McInnes, E H., Engineer, 160 Lambton Quay, Wellington.
McKay, A. W., Dominion Museum, Wellington.
McKenzie, C. J., Public Works Department, Wellington.
Maclaurin, J. S., D.Sc., F.C.S., Dominion Laboratory, Wellington.
MacLean, F. W., M.Inst.C.E., Chief Engineer, Head Office, Railway Department, Wellington.
McSherry, Harry, Box 49, Pahiatua.
Marchbanks, J., Harbour Board, Wellington.
Marsden, E., D.Sc., F.N.Z.Inst., Director of Education, Wellington.
Martin, Mrs., Upper Hutt.
Marwick, J., D.Sc., Geological Survey, The Terrace, Wellington.
Maskell, F. G., Victoria University College, Wellington.
Mason, Dr. J. Malcolm, Lower Hutt.
Matheson, W. B., Tiratahi, Eketahuna.
Maxwell, E., Marumarunui, Opunake.
Maxwell, J. P., M.Inst.C.E., 145 Dixon Street, Wellington.
Mestayer, Miss M., Sydney Street, Wellington.
Miles, P. C. V. R., Room 45, G.P.O., Wellington.
Millar, H. M., Public Works, Department, Wellington.
Miller, D., 71 Fairlie Terrace, Kelburn.
Moore, G., Eparaima, via Masterton.
Moore, W., Lancelot, Bank Chambers, Lambton Quay, Wellington.
Moorhouse, W. H. Sefton, 134 Dixon Street, Wellington.
Morgan, P. G., M.A., F.G.S., F.N.Z.Inst., Director of Geological Survey, 156 The Terrace, Wellington.
Morice, J. M., B.Sc., Town Hall, Wellington.
Morrison, J. C., Box 413, G.P.O., Wellington.
Morton, W., Hydro-electric Board, Public Works Department, Wellington.
Myers, J. G.
Neill, J. C., 251 The Terrace, Wellington.
Neill, W. T., Lands and Survey Department, Government Buildings, Wellington.
Newnham, W. L., Public Works Department, Wellington.
Newton, A., care of Newton Engineering Company, Wellington.
Ngata, Hon. A. T., Parliament Buildings, Wellington.

Nicol, John, 57 Cuba Street, Wellington.
Norris, E. T., M.A., Registrar, University of New Zealand, Wellington.
Oliver, W. R. B., F.L.S., F.Z.S., Dominion Museum, Wellington.
Ongley, M., M.A., Geological Survey Department, Wellington.
Orchiston, J., M.I.E.E., 16 Rimu Road, Kelburn.
O'Regan, P. J., 324 Lambton Quay, Wellington.
Orr, Robert, Heke Street, Lower Hutt, Wellington.
Parry, Evan, B.Sc., M.I.E.E., care of Preece Calderwood Rider, 8 Queen Anne's Gate, Westminster, London.
Patterson, Hugh, Engineer, Public Works Department, Wellington.
Peren, G. S., Professor of Agriculture, Victoria University College, Wellington.
Phillipps, W. J., F.L.S., Dominion Museum, Wellington.
Philpott, H. E. R., care of A. D. Riley (Limited), Wellington.
Phipson, P. B., F.C.S., care of J. Staples and Co. (Limited), Wellington.
Pigott, Miss Ellen, M.A., Victoria University College, Wellington.
Pilcher, E. G., 225 The Terrace, Wellington.
Plank, C. S., Telegraph Engineers' Department, G.P.O., Wellington.
Pomare, Hon. Sir Maui, M.P., Wellington.
Ralph, T., 85 Webb Street, Wellington.
Rands, Henry, Wellington Gas Company (Limited), Miramar.
Reakes, C. J., D.V.Sc., M.R.C.V.S., Agriculture Department, Wellington.
Richardson, C. E., P.O. Box 863 (11 Gray Street), Wellington.
Roberts, J. W., 12 Vallance Street, Kilbirnie.
Robertson, Professor P. W., Victoria University College, Wellington.
Robinson, W. D., 274 Taranaki Street, Wellington.
Russell, J. W., Banks College, Wellington.
Sage, Miss, Wellington Girls' College, Wellington.
Salmon, Miss O. K., 100 Coromandel Street, Wellington.
Sangster, Mrs., Ohangai, Hawera.
Saunders, G. F., High School, Hamilton.
Scarfe, W. A., care of Union Steamship Company, Head Office, Wellington.
Schofield, G. H., Sefton Street, Wadestown.
Schofield, Mrs. G. H., Sefton Street, Wadestown.
Seelye, F. T., Dominion Laboratory, Wellington.
Sharp, H., Engineer-in-Chief, Public Works Department, Wellington.
Shrimpton, E. A., Telegraph Department, Wellington.
Sladden, H., Woburn Road, Lower Hutt, Wellington.
Smith, J. R., District Telegraph Engineer, G.P.O., Wellington.
Sommerville, Professor D. M. Y., M.A., D.Sc., F.R.S.E., F.N.Z.Inst., Victoria University College, Wellington.
Sunley, R. M., View Road, Karori.
Sutherland, W. S., "Kawaroa," Oparau Ferry, via Te Awamutu.
Tennant, J. S., Training College, Kelburn.
Thomson, J. Allan, M.A., D.Sc., F.G.S., F.N.Z.Inst., Dominion Museum, Wellington.
Thomson, P., Solicitor, Stratford.
Thomson, W. M., M.A., M.B., Ch.B., Hawera.
Tolley, H. R., 66 Hankey Street, Wellington.
Tombs, H. H., Burnell Avenue, Wellington.
Tomkies, A. E., Chief Electrical Line Inspector, N.Z. Railways.
Toogood, H. F., 11 Grey Street, Wellington.
Treadwell, C. H., 4 Panama Street, Wellington.
Turner, E. Phillips, F.R.G.S., Forestry Department, Wellington.
Uttley, G., M.A., M.Sc., F.G.S., High School, Masterton.
Vickerman, H., M.Sc., Assoc.M.Inst.C.E., Dominion Farmers' Institute, Featherston Street, Wellington.
Waghorn, R. J., Technical High School, Hastings.
Ward, R. H., Taupo.
Warner, —, School-teacher, Upper Hutt.
Waters, R., 71 Fairlie Terrace, Kelburn.
Waterworth, A., 286 Lambton Quay, Wellington.
Webb, E. N., 324 Lambton Quay, Wellington.
Webster, H. A., care of Begg and Co., Manners Street, Wellington.
Westland, C. J., F.R.A.S., Box 63, Apia, Samoa.
Widdop, F. C., District Railway Engineer, Thorndon Office, Wellington.
Wilson, Sir James G., Bull's.
Wood, J., Inspecting Engineer, Public Works Department, Wellington.
Wyles, G. W., Assistant Signal Engineer, Railways, Wellington.
Wynne, H. J., Railway Department, Wellington.
Yates, G., 460 Adelaide Road, Wellington.

ASSOCIATE MEMBERS.

Bryant, D. L., Dominion Laboratory, Wellington.
Castle, Miss A., Dominion Museum, Wellington.
Clarke, C. R., 136 Coutts Street, Kilbirnie.
Cotton, Mrs., Rimu Road, Kelburn, Wellington.
Craig, Miss K. M., 122 Molesworth Street, Wellington.
Foster, L. D., Dominion Laboratory, Wellington.
Haggett, F. G., Trelissick Crescent, Ngaio.
Jackson, G. H., Box 692, G.P.O., Wellington.
Livermore, L. C., 79A Vivian Street, Wellington.

Matthews, K. E., Dominion Laboratory, Wellington.
Munro, A. D., Victoria College, Kelburn.
Perks, T. E., Dominion Laboratory, Wellington.
Pragnell, Miss, Victoria College, Kelburn.
Richardson, Miss, Lands and Survey Department, Wellington.
Rump, B., 3 Freeling Street, Island Bay.
Short, H. F., Naval Intelligence Office, Harcourt's Buildings, Wellington.
Thomas, H., P.O. Box 199, Wellington.
Tripe, Mrs. J., Selwyn Terrace.
Wood, C. W., Dominion Laboratory, Wellington.

AUCKLAND INSTITUTE

[* Honorary and life members.]

Abbott, R. H., City Chambers, Queen Street, Auckland.
Abel, R. S., care of Abel, Dykes, and Co., Shortland Street, Auckland.
Adams, C. E., B.A., LL.B., Hokitika.
Adams, L., 12 Ewington Avenue, Mount Eden.
Aimer, K. W., Architect, 423 N.Z. Insurance Buildings, Auckland.
Alexander, J., Shortland Street, Auckland.
Alexander, L. W., Cargen Hotel, Auckland.
Algie, Professor R. M., M.A., University College, Auckland.
Alison, Hon. E. W., M.L.C., Devonport Ferry Company, Auckland.
Alison, E. W., jun., Bank of New Zealand Chambers, Swanson Street, Auckland.
Alison, Ernest, Takapuna.
Allum, John, Brunswick Buildings, Auckland.
Ambury, S. J., Greenwood's Corner, Onehunga.
Anderson, E., 4 Bassett Road, Remuera.
Anderson, Professor W., M.A., University College, Auckland.
Andrews, F. N., care of Andrews and Clark, Queen Street, Auckland.
Ardern, P. S., M.A., Remuera.
Arey, W. E., Shortland Street, Auckland.
Armitage, F. L., Gleeson's Buildings, High Street.
Arnold, C., Sanford's Buildings, Auckland.
Arnoldson, L., Quay Street, Auckland.
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Baker, C. C., Durham Street East, Auckland.
Bankart, A. S., Strand Arcade, Queen Street, Auckland.
Bankart, F. J., Swanson Street, Auckland.
Barr, J., Public Library, Wellesley Street, Auckland.
Barr, J. M., Auckland Savings-bank, Queen Street, Auckland.
Bartlett, W. H., Queen Street, Auckland.
Bartrum, J. A., M.Sc., University College, Auckland.
Bates, T. L., Alfred Street, Waratah, Newcastle, New South Wales.*
Bealing, Fred J., Alexander Avenue, Mount Albert, Auckland.
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Binney, E. H., care of Binney and Sons, Customs Street, Auckland.
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Biss, N. L. H., Shortland Street, Auckland.
Biss, Raymond, Victoria Avenue, Remuera.
Black, D. R., Wellesley House, Auckland.
Blomfield, E. C., Shortland Street, Auckland.
Bloodworth, T., 36 Scarborough Terrace, Parnell.
Bloomfield, G. R., "The Pines," Epsom, Auckland.*
Bloomfield, H. R., St. Stephen's Avenue, Parnell.*
Bloomfield, J. L., St. Stephen's Avenue, Parnell.
Boucher, P. T., Piha.
Bradley, Samuel, Onehunga.
Brame, J. W., 69 Crummer Road, Grey Lynn.
Brett, H., *Star* Office, Shortland Street, Auckland.
Brookes, A. E., Okauia, Matamata.
Broomfield, A. G. Le Roy, Colville's Buildings, Swanson Street, Auckland.
Brown, A. G., Lucerne Road, Remuera.
Brown, Miss E., "Kohi," Ascot Avenue, Remuera.
Brown, E. A., Cleave's Buildings, High Street, Auckland.
Brownlee, Mrs., 4 Ascot Avenue, Remuera.
Bruce, W. W., Williamson Chambers, Shortland Street, Auckland.
Buchanan, A., Legal Chambers, Wyndham Street, Auckland.*
Bucknill, Dr. C. E. R., Mount Maunganui, Tauranga.
Buddle, C., Wyndham Street, Auckland.
Buddle, H. D., Victoria Avenue, Remuera.
Burbidge, Professor, University College, Auckland.
Burns, R., Customs Street, Auckland.
Burt, A., care of A. and T. Burt (Limited), Customs Street, Auckland.
Bush, W. E., City Engineer, Auckland.
Butler, J., Kauri Timber Company, Customs Street, Auckland.
Buttle, B., Kaiapoi Woollen Company, Elliott Street, Auckland.

Buttle, G. A., Victoria Arcade, Auckland.
Buttle, J., Selwyn Road, Epsom.
Bygate, J. W., St. Leonard's Avenue, Epsom.
Cadman, F. P., care of Holland, Gillett, and Co., Albert Street, Auckland.
Caldwell, D. R., Cambridge.
Callaghan, F. R., Education Office, Auckland.
Campbell, A. D., Northern Club, Auckland.
Campbell, Hon. J. P., O'Connell Street, Auckland.
Cardno, Miss, Cheltenham Terrace, Devonport.
Carlaw, J., 226 Symonds Street, Auckland.
Carpenter, J. M., Newmarket.
Carse, H., Moata Road, Ellerslie.
Carter, A. M., Hallenstein's Buildings, Queen Street, Auckland.
Carter, C. E., Ewing Street, Takapuna.
Carter, C. M., Lake Town, Takapuna.
Casey, W., Hamilton Road, Ponsonby.
Caughey, A. C., care of Smith and Caughey, Queen Street, Auckland.
Caughey, J. Marsden, care of Smith and Caughey, Queen Street, Auckland.
Chambers, S. G., 108 Victoria Arcade, Queen Street, Auckland.
Chatfield, Dr. H. A., Queen Street, Auckland.
Cheal, P. E., Cameron Road, Remuera.
Choyce, H. C., Remuera Road, Remuera.
Clark, A., Wellesley Street, Auckland.
Clark, H. C., Wellesley Street, Auckland.
Clark, M., Wellesley Street, Auckland.
Clark, R. G., care of Robertson Bros., Quay Street, Auckland.
Clay, T. B., care of S. Vaile and Sons, Queen Street, Auckland.
Clayton, C. Z., Ellerslie.
Clayton, D. L., Kauri Timber Company, Customs Street, Auckland.
Clinch, J. A., Ph.D., Training College, Auckland.
Closs, Dr. J. R., New Lynn.
Coates, T., Orakei.
Cochrane, N. D., 20 Belle View Road, Auckland.
Coe, James, Lucerne Road, Auckland.
Coghlan, W. N., Native School, Omaio, Bay of Plenty.*
Colbeck, W. B., New Zealand Insurance Buildings, Queen Street, Auckland.
Cole, Rev. R. H., Gladstone Road, Parnell.
Coleman, J. W., Lower Queen Street, Auckland.
Colwill, J. H., Swanson Street, Auckland.
Coombes, F. H., Victoria Avenue, Remuera.
Cooper, A. N., Read, Towle, Hellaby, and Cooper, High Street, Auckland.
Cooper, Sir T., Orakei Road, Remuera.
Copeland, M., 22 Sentinel Road, Herne Bay.
Cory-Wright, S., M.Sc., 1 Claybrook Road, Parnell.
Court, A. J., G. Court and Co., Karangahape Road, Auckland.
Court, J., Hamilton Road, Auckland.
Court, J. W., Birkenhead, Auckland.
Cousins, H. G., Principal of the Training College, Auckland.
Craig, J. C., care of J. J. Craig (Limited), Queen Street, Auckland.
Crompton, W. J., 3 Mount Pleasant Road, Mount Eden.
Crook, John, 10 Prospect Terrace, Mount Eden.
Crooks, Miss M. W., Maungawhau Road, Epsom.
Cross, Captain H., Telephone Engineer, Wellesley Street, Auckland.
Dale, T. J., Tennyson Street, Auckland.
Davis, Eliot R., care of Hancock and Co., Customs Street, Auckland.
Davis, Ernest, care of Hancock and Co., Customs Street, Auckland.
Dawes, Miss, University College, Auckland.
Dearsly, H., P.O. Box 466, Auckland.
De Guerrier, F. E., Auckland Tramway Offices, Auckland.
Dempsey, J., Newmarket.
Dennin, John, care of Hon. Sir F. Mitchelson, Waimauku.
Dick, R. J., Leighton's (Limited), High Street, Auckland.
Donald, A. W., care of A. B. Donald, Queen Street, Auckland.
Donald, J. B., P.O. Box 291, Auckland.
Downward, F. N. R., Cambridge.
Draffin, M. K., 423 New Zealand Insurance Building, Auckland.
Eady, A., Queen Street, Auckland.
Earl, F., K.C., Swanson Street, Auckland.
Edgerley, Miss K., Girls' Grammar School, Auckland.
Edmiston, H. J., care of Champtaloup and Edmiston, Queen Street, Auckland.
Egerton, Professor C. W., University College, Auckland.
Ellingham, W. R., Customs Street, Auckland.
Elliot, Sir George, Imperial Buildings, Auckland.
Elliot, W., Imperial Buildings, Queen Street, Auckland.
Ellis, A. F., Argyle Street, Ponsonby.
Endean, J., Waitemata Hotel, Auckland.
Entrican, A. J., Customs Street, Auckland.
Entrican, A. R., University College, Auckland.
Evans, E. W., care of Brown, Barrett, and Co., Customs Street, Auckland.
Ewen, J. F. A., care of Sargood, Son, and Ewen (Limited) Victoria Street West, Auckland.
Fairclough, Dr. W. A., Imperial Buildings, Queen Street, Auckland.
Falla, R. A., 41 Calliope Road, Devonport.
Farrell, R., Anglesea Street, Auckland.
Fenwick, Dr. G., A.M.P. Buildings, Auckland.
Fenwick, R., care of T. and S. Morrin and Fenwick, High Street, Auckland.
Firth, R. W., Wymondsley Road, Otahuhu.
Fisher, F. S., Birkdale.
Fisher, V. F., Birkdale.
Fleming, G., 92 Remuera Road, Remuera.
Fleming, J., 142 Grafton Road, Auckland.
Florance, R. S., Barrister, Russell, Bay of Islands.

Ford, C. Reginald, F.N.Z.I.A., New Zealand Insurance Buildings, Auckland.
Fotheringham, Alexander, 7A Williamson's Chambers, Auckland.
• Fowlds, Hon. G., Queen Street, Auckland.*
Fowlds, G., jun., Queen Street, Auckland.
Fraser, W. M., C.E., Whangarei.
Frater, J. W., Stock Exchange, Auckland.
Gardner, J. L., New Lynn.
Geddes, A., Brown, Barrett, and Co., Customs Street, Auckland.
Gibson, Noel, Dilworth Institute, Remuera.
Gilfillan, H., St. Stephen's Avenue, Parnell.
Gillett, J., care of Hoiland and Gillett, Albert Street, Auckland.
Gillies, A. W., Courtville, Eden Crescent, Auckland.
Girdler, Dr., Khyber Pass Road, Auckland.
Gleeson, J. C., Lower Symonds Street, Auckland.
Goldie, A., Wallace Street, Ponsonby.
Goldie, D., Imperial Buildings, Auckland.
Goldie, H., Imperial Buildings, Auckland.
Gordon, Dr. F. W., Hillsborough.
Graham, A. G., care of Briscoe and Co., Customs Street, Auckland.
Graham, David H., Albert Street, Opotiki.
Graham, G., 25 Grafton Road, Auckland.
Grant, Miss J., M.A., Devonport.
Gray, A., Winstone's Buildings, Queen Street, Auckland.*
Gray, Alan A., care of G. W. Wilton and Co., Shortland Street, Auckland.
Gray, S., Town Clerk, Mount Eden.
Gray, W. A., M.Inst.C.E., Smith's Buildings, Auckland.
Gribbin, G., care of Nicholson and Gribbin, Imperial Buildings, Queen Street, Auckland.
Grierson, H. C., Architect, 423 N.Z. Insurance Building, Auckland.
Griffin, K. M., Government Analyst, Auckland.
Griffin, L. T., F.Z.S., Museum, Auckland.
Gross, R. O., Wairiki Road, Mount Eden.
Gulliver, V., 503 New Zealand Insurance Buildings, Auckland.
Gummer, W. H., N.Z. Insurance Buildings, Auckland.
Gunson, Sir, J. H., C.M.G., C.B.E., Mayor of Auckland.
Haddon, J. G., Wyndham Street, Auckland.
Hall, J. W., P.O. Box 1048, Auckland.
Hamer, W. H., C.E., Harbour Board Offices, Auckland.
Harbutt, S. J., Selwyn Road, Epsom.
Hardie, J. C., High Street, Auckland.
Harding, E., Private Bag, Dargaville.
Hardley, J. W., Customs Street, Auckland.
Harris, Lewis, Huntly.
Harvey, A., Lower Albert Street, Auckland.
Hay, D. A., Montpellier Nursery, Remuera.
Hay, Douglas, Stock Exchange, Queen Street, Auckland.
Hay, Miss, Grafton Road, Auckland.
Henning, G., 36 Remuera Road, Remuera.
Hesketh, H. R., Wyndham Street, Auckland.
Hesketh, S., Wyndham Street, Auckland.
Hill, J. C., care of Hill and Plummer, Queen Street, Auckland.
Hills, F. M., Arney Road, Remuera.
Holderness, D., Harbour Board Offices, Auckland.
Holmden, Dr., Jervois Road, Ponsonby.
Horton, E., *Herald* Office, Queen Street, Auckland.
Horton, H., *Herald* Office, Queen Street, Auckland.
Houghton, C. V., 8 Gladstone Road, Parnell.
Hovell, S. W., Kenny Street, Waihi.
Hudson, C., Mount Eden Road, Auckland.
Hudson, J. H., G.P.O., Auckland.
Hull, Miss Cecil, Girls' Grammar School, Auckland.
Hunter, Ashley, C.E., Swanson Street, Auckland.
Inder, E. W., P.O. Box 1089, Auckland.
Inglis, Dr. R. T., Alfred Street, Auckland.
Jackson, J. H., Customs Street, Auckland.
Jackson, Thornton, Shortland Street, Auckland.
Johnson, C. W., M.A., 30 Brown Street, Ponsonby.
Johnston, Hallyburton, Point Chevalier.
Johnston, J. B., Stewart and Johnston, Wyndham Street, Auckland.
Johnstone, A. H., Fort Street, Auckland.
Joll, L., Mount Eden
Jones, Russell, Grammar School, Auckland.
Kalaugher, J. P., Education Offices, Auckland.
Kenderdine, J., Sale Street, Auckland.
Kent, G. S., St. Stephen's Avenue, Parnell.
Kissling, H. P., St. Stephen's Avenue, Parnell.
Knight, G., Asquith Avenue, Mount Albert.
Laidlaw, R. A., Hobson Street, Auckland.
Lamb, J. A., Arney Road, Remuera.
Lamb, S. E., B.Sc., University College, Auck-Land.
Lamont, T., North Avenue, Devonport.
Lancaster, T. L., M.Sc., University College, Auckland.
Lang, Hon. Sir F. W., Queenstown Road, Onehunga.
Langridge, Cecil, Avondale.
Larner, V. J., Swanson Street, Auckland.
La Roche, Sydney, B.Sc., Wapiti Avenue, Auckland.
La Roche, W. E., Wapiti Avenue, Remuera.
La Roche, W., Wapiti Avenue, Remuera.
Laurie, B. A., care of W. S. Laurie and Co., Customs Street, Auckland.
Leech, E. Duff, Wellesley House, Auckland.
Le Roy, E., 42 Queen Street, Auckland.
Leyland, S. H., Customs Street West, Auckland.
Leyland, W. B., Customs Street West, Auckland.
Leys, Cecil, *Star* Office, Shortland Street, Auckland.
Logan, R., P.O. Box 536, Auckland.

Long, W. H., 16 St. Albans Avenue, Auckland.
Lowe, Dr. De Clive, Lower Symonds Street, Auckland.
Lowe, James C. E., Gas Company, Auckland.
Lunn, A. G., care of Collins Bros., Wyndham Street, Auckland.
Lusk, H. B., M.A., King's College, Remuera.
Lyons, Rev. Father, Coromandel.
McCullough, Hon. W., Thames.
Macdonald, Rev. Angus, New Lynn.
Macdonald, Hugh R., 47 St. Stephen's Avenue, Parnell.
McDonald, Rev. W., Gardner Road, Epsom.
McGregor, W. R., University College, Auckland.
McIlraith, Dr. J. W., 12 Mount Hobson Road, Remuera.
McIntosh, D. T., 5 Claybrook Road, Parnell.
Mackay, G. J., Queen Street, Auckland.
Mackay, J. G. H., Ellison Chambers, Queen Street, Auckland.
Mackenzie, Dr. Kenneth, Princes Street, Auckland.
McKenzie, Captain G., Devonport.
Macky, T. H., care of Macky, Logan, and Co., Elliott Street, Auckland.
McLaughlin, T. M., Phœnix Chambers, Queen Street, Auckland.
Macmillan, C. C., care of Auckland Institute, Auckland.*
McVeagh, James, 410 New Zealand Insurance Buildings, Auckland.
McVeagh, R., O'Connell Street, Auckland.
Mains, T., Papatoetoe.
Mair, S. A. R., Hunterville, Wellington.
Major, C. T., King's College, Remuera.
Makgill, John E., Wapiti Avenue, Epsom.
Makgill, Dr. R. H., Health Department, Wellington.
Mander, F., Ranfurly Road, Epsom.
Marks, L., Chancery Street, Auckland.
Marshall, J., Te Ataahua, Remuera Road.
Mason, Mrs. F., West Town, New Plymouth.
Matthews, H. B., Clonbern Road, Remuera.
Maxwell, L. S., Lower Hobson Street, Auckland.
Merritt, H. T., N.Z. Insurance Buildings, Auckland.
Metcalf, S. H., P.O. Box 1089, Auckland.
Miller, E. V., 71 Upland Road, Remuera.
Miller, E. N., Albert Street, Thames.
Milne, J., care of John Chambers and Son, Fort Street, Auckland.
Milne, Stewart, care of Milne and Choyce, Queen Street, Auckland.
Milsom, Dr. E. H. B., 18 Waterloo Quadrant, Auckland.
Mitchelson, E, P., P.O. Box 873, Auckland.
Mitchelson, Sir E., K.C.M.G., M.L.C., Waitaramoa, Remuera.
Mole, J. B. de, 20 Paget Street, Ponsonby.
Morrison, A. R., Palmerston Buildings, Queen Street, Auckland.
Morton, E., Customs Street, Auckland.
Morton, H. B., Taumata, Wapiti Avenue, Epsom.
Moses, H. C., No Deposit Piano Company, High Street, Auckland.
Mulgan, A. E., *Star* Office, Auckland.
Mullins, P., Shaddock Street, Mount Eden.
Munro, G. H., M.Sc., 96, Grafton Road, Auckland.
Myers, Sir A. M., Queen Street, Auckland.*
Myers, B., Cargen Hotel, Auckland.
Napier, W. J., Napier and Smith, A.M.P. Buildings, Queen Street, Auckland.
Nathan, C. J., Customs Street, Auckland.
Nathan, D. L., Shortland Street, Auckland.
Nathan, N. A., Shortland Street, Auckland.*
Neve, B., M.A., LL.B., Technical College, Wellesley Street, Auckland.
Niccol, G., Customs Street West, Auckland.
Nicholson, O., Imperial Buildings, Queen Street, Auckland.
Oliver, W. R. B., F.L.S., Museum, Wellington.*
Ostler, H. H., Shortland Street, Auckland.
Parr, Hon. Sir C. J., K.C.M.G., M.P., Shortland Street, Auckland.
Parr, P. R., M.Sc., Oaklands, Waikumete.
Parsons, W. B., Colonial Sugar Company, Queen Street, Auckland.
Partridge, H. E., Albert Street, Auckland.
Patterson, D. B., 23 Shortland Street, Auckland.
Peacock, J. A., Queen Street, Auckland.
Perkins, A. W., care of Dalgety and Co., Customs Street West, Auckland.
Petrie, D., M.A., Ph.D., F.N.Z.Inst., "Rosemead," Ranfurly Road, Epsom.
Philcox, T., 11 Fairview Road, Mount Eden.
Pond, J. A., F.C.S., Queen Street, Auckland.
Potter, E. H., P.O. Box 230, Auckland.
Pountney, W. H., Fort Street, Auckland.
Powell, A. W. B., Shortland Street, Auckland.
Powell, F. E., C.E., Ferry Buildings, Queen Street, Auckland.
Poynton, J. W., 55 Epsom Avenue, Mount Eden.
Price, E. A., Cambria Park, Papatoetoe.
Price, T. G., 109 Queen Street, Auckland.
Pryor, S. H., Hillside, New Lynn.
Pulling, Miss, Diocesan School, Epsom.
Purchas, Dr. A. C., Symonds Street, Auckland.
Pycroft, A. T., Railway Offices, Auckland.
Quartley, A. G., Vulcan Lane, Auckland.
Ralph, W. J., Princes Street, Auckland.
Rangi Hiroa, Dr., D.S.O., care of Health Department, Auckland.
Ratcliff, W., P.O. Box 259, Hamilton.
Rawnsley, S., Federal Street, Auckland.
Rayner, Dr. F. J., Queen Street, Auckland.
Reed, Mr. Justice, Supreme Court Wellington.
Reed, Hon. Vernon, Kawakawa.
Renshaw, F., Sharland and Co., Lorne Street, Auckland.
Rhodes, C., "Ronaki," Remuera.
Richardson, J. D., Savings-bank, Newton.
Richmond, H. P., Arney Road, Remuera.
Robb, J., Victoria Avenue, Mount Eden.
Roberton, A. B., Heather, Roberton, and Co., Fort Street, Auckland.

Roberton, Dr. E., Market Road, Remuera.
Robertson, Carrick, Alfred Street, Auckland.
Robertson, James, Market Road Remuera.
Roche, H., Horahora, near Cambridge, Waikato.
Rollett, F. C., *Herald* Office, Queen Street, Auckland.
Ropiha, T, T,. Survey Office, Auckland.
Russell, E. N. A., Princes Street, Auckland.
Russell, John E., Princes Street, Auckland.
Salt, G., MacBride, M.Sc., University College, Auckland.
Saunders, W. R., Commercial Union Insurance Company, Auckland.
Saxton, A. C., Pyrmont, Sydney.
Scott, D. D., Kempthorne, Prosser, and Co., Albert Street, Auckland.
Scott, Rev. D. D., The Manse, Onehunga.
Segar, Professor H. W., M.A., F.N.Z.Inst., University College, Auckland.
Shakespear, Mrs. R. H., Whangaparaoa.
Shannon, J. W., 16 Dromorne Road, Remuera.
Shaw, F., Vermont Street, Ponsonby.
Shaw, H., care of Public Library, Auckland.
Short, W. F., M.Sc., University College, Auckland.
Shrewsbury, H., St. John Avenue, Epsom.
Shroff, H. R., 44 Remuera Road, Remuera.*
Simmonds, Rev. J. H., Wesley Training College, Epsom.
Simson, T., Mount St. John Avenue, Epsom.
Sinclair, G., care of Pilkington and Co., Queen Street, Auckland.
Skeet, H. M., Dilworth Avenue, Remuera.
Sladden, B., P.O. Box 17, Tauranga.
Smith, F. W., 1 Eden Crescent, Auckland.
Smith, Miss H. Seth, Hurstmere Road, Takapuna.
Smith, H. G. Seth, 88 Victoria Avenue, Remuera.*
Smith, S. A., P.O. Box 843, Auckland.
Smith, Mrs. W. H., Princes Street, Auckland.
Smith, W. Todd, St. Helier's Bay.
Somerville, Dr. J., Alfred Street, Auckland.
Somerville, J. M., Birkenhead, Auckland.
Spedding, J. C., Market Road Remuera.
Sperrin-Johnson, Professor J. C., M.Sc., University College, Auckland.*
Stanton, J., Fort Street, Auckland.
Stevenson, Arthur G., Gladstone Road, Mount Albert.
Stewart, D. F., care of R. S. Lamb and Co., 32 Jamieson Street, Sydney.
Stewart, John A., Kainga-tonu, Ranfurly Road, Epsom.
Stewart, R. Leslie, care of Brown and Stewart, Swanson Street, Auckland.
Streeter, S. C., Enfield Street, Mount Eden.
Sullivan, J. J., P.O. Box 1175, Auckland.
Suter, A., 22 Portland Road, Remuera.
Swan, H. C., Henderson.
Talbot, Dr. A. G., A.M.P. Buildings, Queen Street, Auckland.
Taylor, C. N., 2 Oliver Street, Remuera.
Thomas, Professor A. P. W., M.A., F.L.S., F.N.Z.Inst., Mountain Road, Epsom.
Thornes, J., 231, Parnell Road Parnell.
Tilly, C. S. R., 85 Victoria Avenue, Remuera.
Tinne, H., Union Club, Carlton House Terrace, London S.W.*
Tomlinson, L. H., Electrical Construction Company of New Zealand, 52 Fort Street, Auckland.
Townson, W., Thames.
Trounson, J., Northcote.
Tunks, C. J., Shortland Street, Auckland.
Turner, E. C., care of Turner and Sons, Market Square, Auckland.
Upton, J. H., St. Stephen's Avenue, Parnell.
Upton, P., South British Insurance Company, Queen Street, Auckland.
Upton, P. T., P.O. Box 878, Auckland.
Utting, H., Town Clerk, Mount Albert.
Vaile, E. E., Broadlands, Waiotapu.
Vaile, H. E., Queen Street, Auckland.*
Veale, P.O., M.Sc. 1 Beresford Street, Auckland.
Vernon, T. R., 11 Kingsview Road, Mount Eden.
Wade, Dr. Wallace, Elliot Street, New Plymouth.
Wake, F. W., Cleave's Buildings, High Street, Auckland.
Wallace, T. F., 1 Claude Road, One Tree Hill, Auckland.
Walsh, Edmund, 31 Williamson Avenue, Grey Lynn.
Warnock, J. A., 2 King Street, Grey Lynn.
Watt, W. M., Dredging Office, Harbour Board, Auckland.
Waymouth, G. W., Rarere Road, Takapuna.
Wells, T. U., Westbourne Road, Remuera.
Wheelers, Thomas, Stanmore Road, Grey Lynn.
White, P. C., care of S. White and Sons, Customs Street West, Auckland.
White, R. W., Wellington Street, Auckland.
Whitley, W. S., Albert Street, Auckland.
Whitney, C. A., Colonial Ammunition Company, Auckland.
Whittome, F., Newmarket.
Williams, N. T., 74 Arney Road, Remuera.
Williamson, J. D., Northern Club, Auckland.*
Wilson, Andrew, Hillcrest Street, Hamilton East.
Wilson, C. A., P.O. Box 1081, Auckland.
Wilson, F. W., *Herald* Buildings, Auckland.
Wilson, G. A., Wilson and Canham, Ferry Buildings, Auckland.
Wilson, John, 303 New Zealand Insurance Buildings, Queen Street, Auckland.
Wilson, J. A., care of A. Eady and Sons, Queen Street, Auckland.
Wilson, J. M., Portland Road, Remuera.
Wilson, Liston, Upland Road, Remuera.
Wilson, Martyn, Roselle, Lower Remuera.
Wilson, R. M., University College, Auckland.
Wilson, Mrs. R. M., Russell Road, Remuera.
Wilson, W. R., *Herald* Office, Queen Street, Auckland.
Wily, H., Mauku.

Winkelmann, N. H., Victoria Arcade, Auckland.
Winstone, F. M., Claude Road, Epsom.*
Winstone, G., sen., Queen Street, Auckland.
Wiseman, F., Queen Street, Auckland.
Wiseman, J. W., Albert Street, Auckland.
Withy, E., care of Auckland Institute, Auckland.*
Wood, Right Rev. C. J., D.D., England.*
Woollams, W. H., Queen Street, Auckland.
Worley, Professor F. P., D.Sc., University College, Auckland.
Wright, R., care of A. B. Wright and Sons, Commerce Street, Auckland.
Wright, R., Seabrook Avenue, New Lynn.
Wright, R., jun., Seabrook Avenue, New Lynn.
Wyllie, A., C.E., Auckland Power Board, Auckland.
Yates, E., Albert Street, Auckland.
Young, J. L., Henderson and Macfarlane, Customs Street, Auckland.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

[* Life members.]

Acland, Dr. H. T. D., 51 Brown's Road, Christchurch.
Acland, H. D., 42 Park Terrace, Christchurch.
Alexander, R. E., Canterbury Agricultural College, Lincoln.
Allan, H. H., M.A., D.Sc., F.L.S., Feilding.
Anderson, Mrs., Murchison, St. Martin's, Christchurch.
Askew, H. O., M.A., Imperial College of Science and Technology, South Kensington, London S.W. 7.
Bamford, P. G., B.E., Canterbury College.
Barkas, F., Timaru.
Barnett, W. J. F., Cathedral Square, Christchurch.
Bates, D., 22 Webb Street, Christchurch.
Beaven, A. W., care of Andrews and Beaven, Moorhouse Avenue, Christchurch.
Beeby, C. E., Canterbury College, Christchurch.
Belton, F. J. W., care of Gas Company, Christchurch.
Bennett, E. W., M.Sc., Canterbury College, Christchurch.
Berry, R. E., 165 Manchester Street, Christchurch.
Biltcliff, G. S. A., Canterbury College.
Bingham, S. C., 7 Cashel Street, Christchurch.
Bird, J. W., M.A., Wairarapa High School, Masterton.
Bishop, R. C., Gas Office, 77 Worcester Street, Christchurch.
Booth, G. T., 242 Papanui Road, Christchurch.
Borrie, Dr. F. J., 236 Hereford Street, Christchurch.
Borrie, Miss, 236 Hereford Street, Christchurch.
Bowker, George, Timaru.
Boys, Sir Francis, Hereford Street, Christchurch.
Bradley, Orton, Charteris Bay.
Bridge, H. W., Dyer's Pass Road, Cashmere.
Brittin, Guy, F.E.S., Riwaka, Motueka, Nelson.
Broadhead, H. D., M.A., Litt.D., Canterbury College, Christchurch.
Brook, W., M.A., Education Office, Christchurch.
Brown, Professor Macmillan, M.A., LL.D., "Holmbank," Cashmere Hills.*
Burnes, Mrs., Warwick House, 52 Armagh Street, Christchurch.
Burnett, T. D., Cave, South Canterbury.
Calvert, G. G., Canterbury College.
Campbell, J. W., Seaview Road, New Brighton.
Campbell, Professor R. A., Canterbury College, Christchurch.
Candy, Miss A. F., M.A., Canterbury College, Christchurch.
Candy, F. R., care of Tramway Board Office, Christchurch.
Chilton, Professor C., D.Sc., M.A., LL.D., F.N.Z.Inst., F.L.S., Canterbury College, Christchurch.*
Christensen, C. E., Box 38, Te Aroha.
Christian, F. H., Cashel Street, Christchurch.
Clark, W. H., 100 Bealey Avenue, Christchurch.
Coates, C. C., 134 Hereford Street, Christchurch.
Colee, W. C., M.A., Schoolhouse, Waimataitai, Timaru.
Coles, W. R., 358 Gloucester Street, Christchurch.
Condliffe, Professor J. B., M.A., Canterbury College, Christchurch.
Cornes, J. J. S., B.A., B.Sc., Training College, Christchurch.
Cowley, S. R., 156 Antigua Street, Christchurch.
Cox, P. T., care of Anglo-Russian Oil Company, Britannia House, Finsbury Circus, London, E.C. 2.
Dash, Charles, 233 Norwood Street, Beckenham, Christchurch.
Day, James S., care of Dominion Trust Company, 163 Hereford-street, Christchurch.
Deans, James, Homebush.
Deans, John, Kirkstyle, Coalgate.
Deans, William, Sandown, Waddington.
Denham, Professor H. G., M.A., D.Sc., Ph.D., Canterbury College.

Dobson, A. Dudley, M.Inst.C.E., 76 Merivale Lane, Christchurch.
Dorrien-Smith, Major A. A., D.S.O., Tresco Abbey, Scilly, England.
Dougall, J. J., 105 Clyde Road, Christchurch.
Drummond, James, F.L.S., F.Z.S., *Lyttelton Times*, Christchurch.
Duncan, J. S., care of P. and D. Duncan, Tuam Street, Christchurch.
Fairbairn, A., P.O. Box 427, Christchurch.
Farr, Professor C. Coleridge, D.Sc., F.P.S.L., F.N.Z.Inst., Canterbury College, Christchurch.
Ferrar, Miss, 450 Armagh Street, Christchurch.
Fitzgerald, Miss M. S., M.Sc., Canterbury College.
Flesher, J. A., 169 Hereford Street, Christchurch.
Flower, A. E., M.A., M.Sc., Christ's College, Christchurch.
Ford, A. D., 13 Riccarton Road, Christchurch.
Foweraker, C. E., M.A., F.L.S., Canterbury College, Christchurch.
Francis, J. W. H., care of Rhodes, Ross, and Godby, Hereford Street, Christchurch.
Gabites, Dr., Timaru.
Gale, F. H. D., *Sun* Office, Christchurch.
Garnett, J. B., N.D.A., N.D.D., Technical College, Christchurch.
Giles, E. D., Otiritiri, Timaru.
Gilling, C. D., The School, West Eyreton.
Gilling, W. O. R., M.A., B.Sc., 206 Westminster Street, St. Albans, Christchurch.
Godby, Mrs. M. D., 5 Jackson's Road, Fendalton, Christchurch.
Godby, M. H., M.A., B.Sc., 176 Hereford Street, Christchurch.
Goss, W., Peterborough Street, Christchurch.
Gourlay, H., Boys' High School, Christchurch.
Gower, S. W., Canterbury College, Christchurch.
Graham, Charles H. E., School, Tai Tapu.
Gray, G., F.C.S., Lincoln.
Gray, J., 107 Merivale Lane, Christchurch.
Grigg, J. C. N., Longbeach.
Guthrie, Dr. John, Armagh Street, Christchurch.
Hall, G., Hororata.
Hamilton, W. M., 66 Dyers Pass Road, Cashmere.
Hansen, Dr. D. E., M.A., M.Sc., Technical College, Christchurch.
Hardcastle, John, 11 Heaton Street, Timaru.
Harris, H. W., 99 Gloucester Street, Christchurch.
Haynes, E. J., F.Z.S., Canterbury Museum, Christchurch.
Henderson, H., Boys' High School, Christchurch.
Herriott, Miss E. M., M.A., Canterbury College, Christchurch.
Hewitt, S. J., 234 Selwyn Street, Christchurch.
Hight, Professor J., M.A., Litt.D., Canterbury College, Christchurch.
Hilgendorf, F. W., M.A., D.Sc., F.N.Z.Inst., Canterbury Agricultural College, Lincoln.*
Hitchcock, E., 159 Rolleston Street, Christchurch.
Hitchings, C. H., 71 Tweed Street, Richmond.
Hodgson, T. V., F.L.S., Science and Art Museum, Plymouth, England.
Hogg, E. G., M.A., F.R.A.S., Hackthorne Road, Cashmere, Christchurch.
Holford, George, B.Ag., 74 Knowles Street, Christchurch.
Holloway, Rev. J. E., D.Sc., F.N.Z.Inst., Botany Department, Otago University, Dunedin.
Howard, E. J., M.P., care of Trades Hall, Christchurch.
Humphreys, G., Fendalton Road, Fendalton.
Hutton, D. E., 25 Garden Road, Christchurch.
Ingle, Mrs. W., Greyburn, Amberley.
Ingram, John, 39 Mansfield Avenue, St. Albans, Christchurch.
Ironside, Miss A. F., M.A., Training College, Christchurch.
Irving, Dr. W., 56 Armagh Street, Christchurch.
Isitt, L. M., Wigram Aerodrome, Sockburn.
Jameson, J. O., 152 Hereford Street, Christchurch.
Jamieson, W. G., Deans Avenue, Lower Riccarton.
Jeams, Alexander, 24 Peacock Street, Christchurch.
Jobberns, G., M.A., B.Sc., Training College, Christchurch.
Jones, P. H., Schoolhouse, Mount Somers.
Keir, James, care of P. and D. Duncan (Limited), Christchurch.
Kidson, E., M.Sc., Central Weather Bureau, Melbourne.*
Kirkpatrick, W. D., F.R.H.S., M.A., Redcliffs, Sumner.
Knight, H. A., Racecourse Hill.
Laing, R. M., M.A., B.Sc., F.N.Z.Inst., Boys' High School., Christchurch.
Lindsay, Stuart, 18 Sydney Street, Spreydon.
Louisson, Dr. M. G., Royal Exchange Buildings, Cathedral Square, Christchurch.
Lythgoe, J., 266 Bealey Avenue, Christchurch.
McGillivray, Robert, F.L.S., Agriculture Department, Christchurch.
McKay, Dr. W., 45 Guinness Street, Greymouth.
McLean, Mrs. L. J., Sarah Street, Timaru.
Macleod, D. B., M.A., D.Sc., Canterbury College, Christchurch.
Marsh, H. E., Bank of New Zealand, Christchurch.
Marshall, Mrs., 132A North Street, Timaru.
Mayne, J. B., 119 Innes Road, Christchurch.
Mazey, G. A., 52 Fitzgerald Avenue, Christchurch.
Meares, H. O. D., Fendalton.
Mears, F. D., F.C.S., 486 Lincoln Road, Christchurch.
Mill, Dr. Thomas, 10 Jackson's Road, Fendalton.
Milligan, Dr. R. R. D., Pathological Department, Hospital, Christchurch.

Morrison, W. G., Hanmer.
Murray, Miss F. B., M.A., Canterbury College, Christchurch.
Nairn, R., Lincoln Road, Christchurch.
Neal, N. P., B.Ag., St. Andrew's College, Christchurch.
Newburgh, W. S., care of Newburgh, Best, and Co., Cathedral Square, Christchurch.
Nowton, A., Wells, 58 Brittan Street, Linwood.
Oliver, F. S., 84 Hereford Street, Christchurch.
Olliver, Miss F. M., M.A., M.Sc., High School, Waimate.
Ollivier, C. M., St. Martin's, Christchurch.
Orbell, Mrs. E. A., Park Lane, Timaru.
Overton, Miss, 24 Hereford Street, Christchurch.
Owen, H., care of Cook and Ross, Christchurch.
Owen, R. B., 751 Colombo Street, Christchurch.
Packer, J., M.Sc., Canterbury College.
Page, A. W., M.A., 59 May's Road, Papanui.
Page, R. O., M.Sc., 59 May's Road, Papanui.
Page, S., B.Sc., 59 May's Road, Papanui.
Pairman, Dr. J. C., 21 Latimer Square, Christchurch.
Pairman, Dr. T. W., "Moat Knowe," Governor's Bay.
Pannett, J. A., Cashmere Hills.
Pearson, Dr. A. B., Hospital, Christchurch.
Penlington, G., F.N.Z.I.A., Warrington Street, St. Albans.
Pennington, J. H., B.E., Canterbury College.
Polson, J. G., M.A., Training College, Christchurch.
Powell, Professor P. H., M.Sc., Canterbury College, Christchurch.
Prudhoe, J. C., 20 Kidson Terrace, Cashmere.
Purchase, J. E., M.A., F.R.E.S., Training College, Christchurch.
Purnell, C. W., Ashburton.
Raymond, S. G., K.C., Karori Street, Riccarton, Christchurch.
Reece, G. N., Dial Chemical Co., Moorhouse Avenue.
Rennie, J. M., *Sun* Office, Christchurch.
Rhodes, Miss B. H. E., 86 Salisbury Street, Christchurch.
Rhodes, Mrs. J., 16 Sealey Street, Timaru.
Rhodes, J. H., care of Rhodes, Ross, and Godby, 176 Hereford Street, Christchurch.
Rhodes, Hon. Sir R. Heaton, M.P., Tai Tapu.
Ridley, G. S., 25 Matilda Street, Timaru.
Robinson, R. G., Darfield.
Robinson, W. F., F.R.G.S., Canterbury College, Christchurch.
Rodwell, H., Stratford Street, Fendalton, Christchurch.
Rowe, H. V., M.A., Boys' High School, Christchurch.
Sandston, Dr. A. C., Latimer Square, Christchurch.
Sawtell, Mrs. C., 20 Cashel Street, Christchurch.
Scott, M. J., Canterbury Agricultural College, Lincoln.
Seager, S. Hurst, F.R.I.B.A., care of High Commissioner for New Zealand, London.
Shelley, Professor J., M.A., Canterbury College, Christchurch.
Shrubshall, A. H., Bowenvale Avenue, Cashmere.
Simpson, Dr. W., 108 Rugby Street, St. Albans.*
Sims, A., M.A., care of Sims, Cooper, and Co., Hereford Street, Christchurch.
Skey, H. F., B.Sc., Magnetic Observatory, Christchurch.
Skinner, W. H., 3 York Terrace, New Plymouth.
Smith, Hon. G. J., River Road, Opawa.
Speight, Professor R., M.A., M.Sc., F.G.S., F.N.Z.Inst., Canterbury Museum, Christchurch.
Stead, E. F., Ilam, Riccarton.
Steele, G. P., 213 Manchester Street, Christchurch.
Stevenson, Dr. J., Fendalton.
Stevenson, James, Flaxton.
St. John, Charles E., 745 Colombo Street, Christchurch.
Stone, T., *Lyttelton Times* Office, Christchurch.
Strachan, J. E., M.A., Rangiora.
Struthers, J., M.A., Boys' High School, Christchurch.
Sullivan, D. G., M.P., Christchurch.
Sylvester, S. J. H., Canterbury College, Christchurch.*
Symes, Langford P., 20 May's Road, Papanui.
Symes, Dr. W. H., M.B., B.Sc., 63 Worcester Street, Christchurch.*
Tapley, J. F., Governor's Bay.
Taylor, G. J., 440 Madras Street, St. Albans.
Telford, Dr. T. F., Government Buildings, Christchurch.
Thacker, Dr. H. T. J., B.A., 43 Knowles Street, Christchurch.
Thompson, A. H., Monck's Spur, Redcliffs.
Tonnoir, A. L., Canterbury Museum, Christchurch.
Trimnell, C. B., care of Bing, Harris, and Co., Ltd., 68 Lichfield Street, Christchurch.
Tripp, C. H., M.A., Timaru.*
Turner, H. S. E., 36 Brown's Road, St. Albans.
Unwin, Dr. W. H., Church Street, Timaru.
Vangioni, L. J., Akaroa.
Vincent, Spencer W., Box 91, Christchurch.
Waddell, John, 30 Strickland Street, Christchurch.
Wall, Professor A., M.A., Canterbury College, Christchurch.
Waller, F. D., B.A., West Christchurch District High School.
Ward, F. E., Agriculture Department, Christchurch.
Way, G. E., 20 Helmore's Road, Fendalton, Christchurch.*
Weatherburn, Professor C. E., Canterbury College, Christchurch.
Weston, G. T., B.A., LL.B., 152 Manchester Street, Christchurch.
Whetter, Dr. J. P., 211 Gloucester Street, Christchurch.

Widdowson, Dr. H. L., 4 Oxford Terrace, Christchurch.
Wigram, Hon. H. F., M.L.C., 1 Armagh Street, Christchurch.
Wild, L. J., M.A., B.Sc., F.G.S., Feilding.
Wilding, Frank S., care of Wilding and Acland, Hereford Street, Christchurch.
Wilkins, T. J. C., B.A., Schoolhouse, Pleasant Point, South Canterbury.
Williams, C. J. R., M.Inst.C.E., Hackthorne Road, Cashmere, Christchurch.
Withell, J. R., Boys' High School, Christchurch.
Wright, A. M., A.I.C., F.C.S., 482 Lincoln Road, Christchurch.

OTAGO INSTITUTE.

[* Denotes a life member.]

Adams, Professor T. D., M.A., care of Otago University.
Aitken, Mrs. M. W., M.Sc., Royal Botanic Gardens, Edinburgh.
Allan, R. S., M.Sc., Sedgwick Museum, Cambridge University.
Allen, Sir James, High Commissioner's Office, London.*
Anderson, W. D., 32 Lynwood Avenue, Dunottar.
Anderson, Miss A. C., Macandrew Bay.
Angell, S., Commercial Bank of Australia, Princes Street, Dunedin.
Anscombe, E., 171 Princes Street, Dunedin.
Bain, A., B.A., Education Office, Dunedin.
Balk, O., 13 Driver Street, Maori Hill.
Barnett, Dr. L. E., Stafford Street, Dunedin.
Barron, Miss Vida, M.A., 44 Queen Street, Dunedin.
Bathgate, Alex., 85 Glen Avenue, Dunedin.*
Bathgate, Dr. W. J., 76 Stuart Street, Dunedin.
Beal, L. O., Stock Exchange Buildings, Dunedin.
Beeson, J. R., 281 George Street, Dunedin.
Begg, J. C., F.R.A.S., Fifield Street, Roslyn.
Begg, Mrs. A. C., 31 Ross Street, Roslyn.
Bell, A. Dillon, Shag Valley.*
Bell, Professor R. J. T., M.A., D.Sc., Otago University.
Bell, Professor R. C., D.D.S., Dental School, Otago University.
Benham, Professor W. B., M.A., D.Sc., F.R.S., F.N.Z.Inst., Otago Museum.*
Benson, Gerald, 62 Manor Place, Dunedin.
Benson, Professor W. N., B.A., D.Sc., F.G.S., Otago University.
Birrell, W. J., care of Robin and Co., corner Castle and Hanover Streets, Dunedin.
Black, Alex., 82 Clyde Street, Dunedin.*
Black, James, care of Cossens and Black, 164 Crawford Street, Dunedin.
Borlace, W., Lands Office, Dunedin.
Bowie, Dr. J. T. London Street, Dunedin.
Bowron, G. W., 426 Moray Place, Dunedin.
Brasch, H., 99 London Street, Dunedin.
Bremner, R. S., A.M.P. Buildings, Dunedin.
Brown, A. T., Princes Street South, Dunedin.
Browne, R. A. S., care of Post-office, Morrinsville.
Buchanan, N. L., 44 Bronte Street, Nelson.*
Burton, Miss I. H. F., 12 Alma Street, Dunedin.
Butler, J. G., Lynwood Avenue, Dunottar.
Carter, C. L., M.Sc., A.I.C., 6 Carr Street, North-east Valley.
Chamberlain, C. W., 6 Regent Road, Dunedin.*
Chapman, Sir F. R., Wellington.
Chapman, C. R., 53 Manor Place, Dunedin.*
Christian, E., 27 Maitland Street, Dunedin.
Christie, Thomas R., 152 Cargill Street, Dunedin.
Clarke, C. E., 35 Octagon, Dunedin.
Clarke, E. S., Woodhaugh.
Cook, S. R., 66 Elm Row, Dunedin.
Crawford, W. J., 123 High Street, Dunedin.
Dalrymple, Rev. A. M., M.A., 33 Highgate, Roslyn.
Davidson, E., 45 Newington Avenue, Dunedin.
Davies, Rev. E., 5 Dunblane Street, Roslyn.
Davies, O. V., 109 Princes Street, Dunedin.
Don, W. G., care of Crust and Crust, Manse Street, Dunedin.
Donn, R., Training College, Dunedin.
Douglas, J. S., Frederick Street, Dunedin.
Duncan, P., "Tolcarne," Maori Hill.
Duncombe, Mrs. T. A., Varde Orchard, Earnscleugh, Alexandra.
Dunlop, James, Box 74, Dunedin.
Dunn, L. R. L., M.Sc., 667 Castle Street, Dunedin.
Dutton, Rev. D., F.G.S., F.R.A.S., 22 Passmore Crescent, Maori Hill.*
Edgar, James, care of Victoria Insurance Company (Limited).
Farnie, Miss W., M.A., Waitati Girls' High School, Oamaru.
Fea, W. B. M., 22 Highgate, Roslyn.
Fels, W., 84 London Street, Dunedin.*
Fenwick, Cuthbert, Box 82, Dunedin.*
Fenwick, Sir G., *Otago Daily Times* Office.
Ferguson Dr. Sir H. L., C.M.G., "Wychwood," Musselburgh Rise.*
Finlay, H. J., 10 Pine Hill Terrace, Dunedin.
Fitchett, Dr. F. W. B., 8 Pitt Street, Dunedin.
Fleming, T. R., M.A., LL.B., Education Office, Invercargill.
Fowler, H., Silveracres, Anderson's Bay, Dunedin.
Fowler, J. M., Branxholme, Southland.

Frye, Charles, Gasworks, Caversham.
Fyfe, H. E., 27 Richmond Street, Dunedin.
Gardner, W., care of H. B. Galland, Kelvin Road, North-east Valley.
Garrow, Professor J. M. E., LL.B., Victoria College, Wellington.*
Gaudin, J. H., 111 Moray Place, Dunedin.
George, Charles E., 15 Filluel Street, Dunedin.
Gilkinson, R., 29 Highgate, Roslyn.*
Goyen, P., F.L.S., 136 Highgate, Roslyn.*
Gray, J. A., 762 Cumberland Street, Dunedin.
Green, E. S., Education Office, Dunedin.
Guthrie, H. J., 426 Moray Place East, Dunedin.
Hall, Dr. A. J., 36 Stuart Street, Dunedin.
Hanlon, A. C., Moray Place, Dunedin.
Harris, M., Medical School, King Street, Dunedin.
Hector, Dr. C. M., Medical School, Dunedin.
Helmkey, J. J. H., George Street, Dunedin.
Henderson, M. C., Electrical Engineer's Office, Cumberland Street, Dunedin.
Hendry, Mr. James.
Hercus, G. R., 33 Albert Street, Dunedin.
Hercus, Dr. C. E., M.D., D.S.O., O.B.E., B.D.S., D.P.H., Medical School, King Street, Dunedin.
Hinton, J. W., M.Sc., Emmanuel College, Cambridge.
Hodson, J., 609 Castle Street, Dunedin.
Hoffman, G., 215 Highgate.
Holloway, Rev. J. E., D.Sc., F.N.Z.Inst., care of Museum, King Street, Dunedin.
Hooper, W. L., P.O. Box 17, Dunedin.
Howard, B., M.A., Boys' High School, Dunedin.
Howes, Miss Edith, Rawhiti Street, Sunshine.*
Howes, W. G., F.E.S., 432 George Street, Dunedin.
Hudson, E. R., B.Sc., B.Ag., Training College.
Inglis, Professor J. K. H., M.A., D.Sc., F.I.C., Otago University.
Jack, Professor R., D.Sc., Otago University.
Jeffrey, William, care of Brown, Ewing, and Co., Dunedin.
Joachim, Miss M. E., 4 Beaumont Road, Mornington.
Johnson, J. T., 46 Littlebourne Road, Dunedin.
Johnson, Dr. Owen, Invercargill.
Kay, J., 257 George Street, Dunedin.
Kaye, William T. O., Normal School, Dunedin.
Kennedy, A. R., Registrar's Office, Lower High Street, Dunedin.
Kirkland, C. J., Dental School, Dunedin.
Lawson, Professor R., M.A., Litt.D., Otago University.
Lee, R., P.O. Box 363, Dunedin.
Levi, A. A., M.Sc., Club House, Moray Place, Dunedin.
Lilly, L. G., 124 London Street, Dunedin.
Lowry, J. M., Public Works Department.
Mackie, A., Test-room, Cumberland Street, Dunedin.
Malcolm, Professor J., M.D., Otago University.
Mandeno, H., New Zealand Express Company's Buildings.
Marshall, Angus, B.A., Technical College.
Martin, W., B.Sc., 21 Musselburgh Rise.
Marwick, Miss T. C., M.Sc., Physics Department, Victoria College, Wellington.
McCurdie, W. D. R., Borough Engineer, Te Awamutu.*
McElrea, W., 138 St. David Street, Dunedin.
McKellar, Dr. T. G., Pitt Street, Dunedin.
McKerrow, Miss K., 167 York Place, Dunedin.
McNair, J., Railway Engineer's Office, Invercargill.
Meenan, J., 79 Cargill Street, Dunedin.
Melland, E., Alport, near Bakewell, Derbyshire, England.*
Merrington, Rev. Dr., First Church Manse, Dunedin.
Michaelis, W. R., Schoolhouse, Alexandra.
Milnes, J. W., 39 Lees Street, Dunedin.*
Moir, G. M., M.Sc., 37 Cole Street, Caversham.
Moore, J. A., M.A., B.Sc., Training College.
Moore, Dr. S. A., Security Buildings, Stuart Street, Dunedin.*
Morrell, W. J., M.A., Boys' High School.*
Munro, Alex., 4 Manuka Street, Dunottar.
Nevill, Canon, St. Paul's Vicarage, 6 Heriot Row.
Newlands, Dr. W., 12 London Street, Dunedin.
Nimmo, R. R., B.Sc., 16 Neidpath Street, Mornington.
Northcroft, E. F., M.Sc., Biological Laboratory (Private Bag), Wellington.
Olds, E. H., Municipal Baths, Moray Place, Dunedin.
Palmer, Alex., 21 Albert Street, St. Clair.
Park, Professor J., F.G.S., F.N.Z.Inst., Otago University.*
Pearcey, B. W., B.Sc., 29 Carr Street, Dunedin.
Penseler, R. G., B.Sc., 122 Dundas Street, Dunedin.
Pickerill, Professor H. P., M.D., B.D.S., Otago University.
Poppelwell, D. L., Gore.
Price, W. H., care of Donald Reid and Co., Vogel Street, Dunedin.*
Ramsay, Professor H., M.A., Otago University.
Richards, Rev. Bishop, See House, 2 Leith Road, Maori Hill.
Riley, Dr. F. R., 346 George Street, Dunedin.
Ritchie, Dr. Russell, 400 George Street, Dunedin.
Roberts, E. F., 128 Highgate, Roslyn.
Roberts, Sir John, C.M.G., Littlebourne.*
Robertson, John, B.A., B.Sc., 47 Highgate, Roslyn.
Ross, T. C., care of Ross and Glendining (Limited).
Routledge, W. R., 14 Norfolk Street, St. Clair.
Salmond, J. L., National Bank Buildings.
Sandle, Major S. G., Defence Office, Palmerston North.
Sargood, Percy R., "Marinoto," Newington.
Shacklock, J. B., Bayfield, Anderson's Bay.

Shortt, F. M., care of John Chambers and Sons, Stuart Street.
Sim, Sir William, Musselburgh Rise.*
Simpson, George, jun., Russell Street, Roslyn.
Simpson, George, sen., Russell Street, Dunedin.
Skinner, H. D., B.A., Museum, King Street, Dunedin.
Sligo, Mr. Alex., care of Mills, Dick, and Co., Dunedin.
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Smith, J. C., care of Vernon Smith, George Street, Dunedin.*
Smith, H. McD., Union Bank Buildings.
Smith, Miss M., 44 Duke Street, Dunedin.
Somerville, T., care of Coulls, Somerville, and Wilkie, Dunedin.
Stark, James, care of Kempthorne, Prosser, and Co.
Steele, R. H., 69 St. David Street, Dunedin.
Stewart, R. T., 21 Gamma Street, Roslyn.
Stewart, Hon. W. Downie, M.P., LL.B., 11 Heriot Row, Dunedin.
Strong, Professor, care of Otago University.
Stout, Sir Robert, K.C.M.G., Wellington.*
Tannock, D., Botanical Gardens.
Tennent, R. B., Bangor Terrace, Kew.
Theomin, D. E., 42 Royal Terrace, Dunedin.
Theomin, E., 8 Royal Terrace, Dunedin.
Thomson, W. A., Ferntree House, 75 Half-way Bush.
Thomson, Hon. G. M., F.L.S., F.N.Z. Inst., M.L.C., 99 Eglinton Road, Mornington.*
Thomson, G. S., B.Sc., 99 Eglinton Road, Mornington.
Thomson, J. S., F.C.S., care of Thomson's Limited, Police Street, Dunedin.
Thornton, Miss M., Training College.
Tily, H. S., care of Customhouse, Dunedin.
Tucker, A. W., Training College.
Turnbull, Miss M. I., M.A., 449 Leith Street, Dunedin.
Waite, Major F., D.S.O., Hillfoot, Waiwera South, Dunedin.
Waters, Professor D. B., A.O.S.M., Otago University.
White, Professor D. R., M.A., 83 St. David Street, Dunedin.*
White, Mr. D. R., Public Trust Office, Dunedin.
Wilkinson, H. K., 33 Royal Terrace, Dunedin.
Williams, J., B.Sc., F.C.S., Otago Boys' High School.
Williams, W. J., City Engineer's Office.
Wilson, G. T. B., 1 Bright Street, Belleknowes.
Wingfield, J. E., 655 Castle Street, Dunedin.
Young, Dr. James, Don Street, Invercargill.
Young, Maxwell W., F.C.S., care of Fish-hatchery, s.s. "Tarewai," Port Chalmers.
Yuille, Rev. Tulloch, Driver Street, Maori Hill.

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Andersen, Miss A. M., Napier.
Anderson, Andrew, Napier.
Armour, W. A., M.A., M.Sc., Boys' High School, Napier.
Ashcroft, Mrs., Napier.
Ashcroft, P., Napier.
Asher, Rev. J. A., Napier.
Bagley, C. J.
Bennett, H. M., Napier.
Berry, Dr. J. A.
Black, J.
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Costello, Dr. J.
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De Castro, F. K.
Dinwiddie, B., Napier.
Dinwiddie, W., Napier.
Dolan, B. J.
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Edmundson, J. H., Napier.
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Gleadow, J.
Graham-Robertson, Dr. F.
Greig, Miss V.
Guthrie-Smith, H., Tutira.
Harding, J. W., Mount Vernon, Waipukurau.
Harding, T. B.
Harding, W. A., Napier.
Harwood, W. G.
Harwood, Mrs. W. G.
Hay, Leslie, Napier.
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Hill, Bromley.
Hill, H., B.A., F.G.S., Napier.
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Hutchinson, F., jun., Rissington.
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Kennedy, C. D., Napier.
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Leahy, Dr. J. P., Napier.

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Mitchell, W. P.
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Moore, Dr. W. W., Napier.
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Nelson, George.
Oates, William, J. P., Tokomaru Bay.
Ormond, Frank.
Ormond, G. C., Mahia.
O'Ryan, W., Waipiro Bay.
Pallot, A. G., Napier.
Pallot, Mrs. R., Napier.
Pidduck, H. A.
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Whetter, R. G., Napier.
Williams, F. W., Napier.
Williams, Ven. Archdeacon H. W., Gisborne.
Wilson, A. H.
Wilson, S. H. J.
Wilton, T. J., Port Ahuriri.
Woodward, M.

NELSON INSTITUTE.

Askew, Rev. C. F., The Deanery, Nelson.
Bartel, J. G., Collingwood Street.
Bishop, L., Cawthron Institute.
Bruce, James, Britannia Heights.
Bruce, James, Cawthron Institute.
Caradus, E., College House, Waimea Road.
Crequer, V. G., Halifax Street.
Cunningham, G., Wainui Street.
Curtis, Dr. K. M., Cawthron Institute.
Curtis, W. S., Tasman Street.
Davies, W. C., Cawthron Institute.
Duncan, H. R., Hardy Street.
Easterfield, Professor, Cawthron Institute.
Field, T. A. H., Rocks Road.
Gibbs, F. G., Collingwood Street.
Gibbs, Dr. S., Hardy Street.
Glasgow, J., Stoke.
Harrison, H., Cawthron Institute.
Hunter-Brown, H., Tory Street.
Hunter-Brown, Mrs. H., Tory Street.
Jamieson, Dr., J. P. S., Hardy Street.
Johnston, Dr. W. S., Hardy Street.
Kelly, R. H., 26 Hampden Street West.
Kemp, G. T., Collingwood Street.
Knapp, F. V., Alfred Street.
Maddox, F. W.
McKay, J. G., Boys' College.
Moller, B. H., Collingwood Street.
Moncrieff, Captain M. M., The Cliffs.
Moncrieff, Mrs. M. M., The Cliffs.
Morley, E. L., Waimea Street.
Mules, Bishop, Trafalgar Square.
Murray, Miss B. J., Cawthron Institute.
Philpott, A., Cawthron Institute.
Rigg, T., Cawthron Institute.
Rix-Trott, H., Hardy Street.
Rout, W., Hardy Street.
Russell, J., Sunnybank, Bronte Street.
Sadlier, Bishop, Wath Brow, Brougham Street.
Taylor, J., 84 Haven Road.
Tillyard, Dr. R. J., Maitai Lodge.
Turnbull, T. A., Hardy Street.
Wharton, Miss B. A., Maitai Bank.
Wharton, G. E., Maitai Bank.
Whitwell, F., Drumduan, Suburban North.
Worley, Miss, Trafalgar Street South.

NOTE.—Associates, who are not entitled to the *Transactions*, are omitted.

MANAWATU PHILOSOPHICAL SOCIETY.

[* Life members.]

Akers, H., Duke Street.
Bagnall, H. G., 30 Te Aweawe Street.
Barnett, Dr. E. C., M.R.C.S., M.R.C.P., Fitzherbert Street.
Batchelar, J. O., Willow Bank.
Bayly, Mrs., Patea.
Bendall, W. E., Dairy Union.
Bennett, G. H., The Square.
Bett, D. H. B., M.B., Ch.B., M.R.C.S., M.R.C.P., Broad Street.
Blackbourne, Rev. H. G., M.A., Vicarage.
Burges, A., 139 Featherston Street.
Callanan, F., Bainesse.
Cameron, W. B., 24 Russell Street.
Cameron, W. H. L., Queen Street.
Canton, H. J., Waldegrave Street.
Clausen, C. N., Rangitikei Street.
Cockayne, A. H., Wellington.
Cohen, M., Broad Street.
Collinson, L. H., The Square.
Crabb, E. H., College Street.
Cullen, Mrs., North Street.
Cunningham, G. H., Department of Agriculture.
Edwards, R., C.E., Duke Street.
Eliott, M. A., The Square.
Fitzherbert, W. L., Broad Street.
Fuller, R. A., Alexandra Street.
Gardner, Captain F. S., Bank of New Zealand, Sydney.*
Gerrand, J. B., The Square.
Grace, R. H. F., National Bank.
Graham, A. J., The Square.
Grigor, A., National Bank.
Hannay, A., care of Manson and Barr.
Hepworth, H., The Square.
Hodder, T. R., Rangitikei Street.
Holben, E. R. B., Rangitikei Street.
Holbrook, H. W. F. 84 Rangitikei Street.
Hopwood, A., Main Street.
Hughes, J. R., C.E., The Square.
Hunter, W., 15 Rangitikei Street.
Hurley, E. O., The Square.
Johnston, J. Goring, Oakhurst.
Keeling, G. W., College Street W.
Larcomb, E., C.E., Roy Street.
Larcomb, P., Roy Street.
Mahon, A., The Square.
Merton, J. L. C., LL.B., Rangitikei Street.
Miller, J., R.C.S.E., L.R.C.P.E., L.R.F.P. and S.G.
Mills, Miss C. B., M.A., Girls' High School.
Moore, Miss.
Murray, J., M.A., High School.
Nash, N. H., The Square.
Needham, F., Rangitikei Street.
Oakley, F. J., Rainforth Street.
Opie, F. D., Technical School.
Oram, M. H., M.A., LL.B., Rangitikei Street.
Park, W., F.R.H.S., College Street.
Peach, Dr. C. W., M.B., C.M., Broad Street.
Pigott, Miss E., 79 College Street.
Poynton, J. W., S.M., Auckland.*
Ross, R., Ferguson Street.
Russell, W. W., Rangitikei Street.
Salmon, C. T., Assoc. in Eng., Canterbury College, Rangitikei Street.
Seifert, A., George Street.
Seifert, H., Featherston Street West.
Seifert, L., George Street.
Sheppard, F. J., Rangitikei Street.
Sim, E. Grant, Rangitikei Street.
Sinclair, N. H., Allen Street.
Smith, W. W., F.E.S., Public Reserve, New Plymouth.
Stevens, J. H., Church Street.
Stevenson, J. C., High School.
Stowe, Dr. W. R., M.R.C.S., M.R.C.P., Linton Street.
Sutherland, A., Boundary Road.
Taylor, C., George Street.
Turner, W., Queen Street.
Welch, W., F.R.G.S., Mosman's Bay, N.S.W.
West, E. V., King Street.
Whitaker, A., Grey Street.
Wilson, Miss D., Rangitikei Street.
Wilson, Miss E. Carncot, Rangitikei Street.*
Wood, J. R., Duke Street.
Wright, A. H. M., College Street.
Young, H. L., Cuba Street.

WANGANUI PHILOSOPHICAL SOCIETY.

[* Life member.]

Aldis, Morton, Wicksteed Place, Wanganui.
Allison, Alexander, 4 Cambrae Place, Aramoho.
Allison, Thomas, 54 Glasgow Street, Wanganui
Amess, A. H. R., M.A., Collegiate School, Wanganui.
Babbage, C. W., Main North Road, St. John's Hill, Wanganui.
Bassett, W. G., St. John's Hill, Wanganui.
Battle, T. H., Architect, Wanganui.
Blair, Alan, care of Wanganui Brewery Company, Wanganui.
Brown, C. P., M.A., LL.B., College Street, Wanganui.
Burnet, J. H., St. John's Hill, Wanganui.
Cowper, A. E., Victoria Avenue, Wanganui.
Crow, E., Wanganui.
Cruickshank, Miss, M.A., M.Sc., Girls' College, Wanganui.

Currie, G., St. John's Hill, Wanganui.
D'Arcy, W. A., 11 Campbell Street, Wanganui.
Downes, T. W., River Trust Board, Wanganui.
Drew, Harry, Victoria Avenue, Wanganui.
Duigan, Herbert, Ridgway Street, Wanganui.
Ford, C. R., F.R.G.S., College Street, Wanganui.
Gibbons, Hope, Wanganui East.
Hall, William, Jockey Club Office, Maria Place, Wanganui.
Hatherly, Henry R., M.R.C.S., Gonville, Wanganui.*
Jack, J. B., St. John's Hill, Wanganui.
Jones, Lloyd, Victoria Avenue, Wanganui.
Liffiton, E. N., J.P., Ridgway Street, Wanganui.
McBeth, J. D. W., Wicksteed Place, Wanganui.
McFarlane, D., Ridgway Street, Wanganui.
Marshall Professor P., M.A., D.Sc., F.G.S., F.N.Z.Inst., Collegiate School, Wanganui.
Miles, F. F., M.A., Collegiate School, Wanganui.
Murdoch, R., P.O. Box 221, Wanganui.
Murray, J. B., St. John's Hill, Wanganui.
Neame, J. A., M.A., 47 Bell Street, Wanganui.
Park, G., B.Ecom., Technical College, Wanganui.
Robertson, A. C., Papaiti, Wanganui.
Stevenson, Russell, Wicksteed Place, Wanganui.
Sturge, A. C., M.A., Hurwoath School, Wanganui.
Sutherland, R. A. S., M.Sc., Collegiate School, Wanganui.
Talboys, F. P., Tramways Manager, Wanganui.
Ward, J. T., Victoria Avenue, Wanganui.*
Watt, J. P., B.A., LL.B., Ridgway Street, Wanganui.
Watt, M. N., F.E.S., St. John's Hill, Wanganui.
Wilson, Alexander, M.D., Wickestead Street, Wanganui.

NOTE.—This list is not up to date, the Wanganui Philosophical Society having failed to send in report and balance-sheet and amended list.

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New Zealand.

Auckland University : *Calendar.*
Geological Survey : *Bulletins.*
Houses of Parliament : *Journals* and *Appendix.*
Journal of Agriculture.
Journal of Science and Technology.
New Zealand Employers' Federation : *Industrial Bulletin.*
New Zealand Official Year-book.
Polynesian Society : *Journal.*
Statistics of New Zealand.

Australia.

Australasian Association for the Advancement of Science : *Report.*
Australasian Institute of Mining Engineers : *Proceedings.*
Australian Antarctic Expedition, 1911–14 : *Reports.*
Australian Forestry Journal.
Commonwealth of Australia, Fisheries : *Parliamentary Report.*
Institute of Science and Industry of Australia : *Bulletins.*
Institution of Engineers of Australia : *Transactions ; Quarterly Bulletin.*
National Research Council of Australia : *Science Abstracts.*

New South Wales.

Agricultural Department, N.S.W. : *Agricultural Gazette.*
Australian Museum, Sydney : *Records ; Annual Report.*
Botanic Gardens and Government Domains, N.S.W. : *Report.*
Critical Revision of the Genus Eucalyptus.
Department of Mines and Geological Survey : *Annual Report ; Mineral Resources ; Bulletins.*
Linnean Society of N.S.W. : *Proceedings.*
Northern Engineering Institute of N.S.W. : *Papers.*
Public Health Department, N.S.W. : *Annual Report.*

Queensland.

Geological Survey of Queensland : *Publications.*
Queensland Naturalist.
Royal Geographical Society : *Journal.*
Royal Society of Queensland : *Proceedings.*

South Australia.

Adelaide Chamber of Commerce : *Annual Report.*
Department of Chemistry, South Australia : *Bulletins.*
Mines Department and Geological Survey of South Australia : *Mining Operations ; G.S. Bulletins and Reports ; Metallurgical Reports ; Synopsis of Mining Laws.*
Public Library, Museum, and Art Gallery of South Australia : *Annual Report.*
Royal Society of South Australia : *Transactions and Proceedings.*

Tasmania.

Royal Society of Tasmania: *Papers and Proceedings.*

Victoria.

Advisory Committee: *Report on Brown Coal.*
Department of Agriculture: *Journal.*
Field Naturalists' Club of Victoria: *Victorian Naturalist.*
Mines Department and Geological Survey of Victoria: *Annual Report; Bulletins; Records.*
Public Library, Museum, and National Art Gallery of Victoria: *Annual Report.*
Royal Society of Victoria: *Proceedings.*

Western Australia.

Geological Survey of Western Australia: *Bulletins.*
Royal Society of Western Australia: *Journal and Proceedings.*

United Kingdom.

Board of Agriculture and Fisheries: *Fishery Investigations.*
Botanical Society of Edinburgh: *Transactions and Proceedings.*
British Association for the Advancement of Science: *Report.*
British Astronomical Association: *Journal; Memoirs; List of Members.*
British Museum: *Catalogues; Guides; Scientific Reports of British Antarctic Expedition, 1910.*
Cambridge Philosophical Society: *Proceedings.*
Cambridge University Library: *Report.*
Department of Scientific and Industrial Research: *Reports.*
Dove Marine Library: *Report.*
Edinburgh Geological Society: *Transactions.*
Geological Department, Glasgow University: *Papers; Monographs.*
Geological Society, London: *Quarterly Journal.*
Geological Survey of Great Britain: *Summary of Progress.*
Geologists Association, London: *Proceedings.*
Handbooks, Commercial Towns, England.
H.M. Stationery Office, London: *Monthly Circular.*
Imperial Bureau of Entomology: *Review of Applied Entomology.*
Imperial Institute: *Bulletins.*
Institution of Civil Engineers: *Report.*
Leeds Geological Association: *Transactions.*
Leeds Philosophical and Literary Society: *Annual Report.*
Linnean Society: *Journal* (Botany); *Proceedings; List of Members.*
Literary and Philosophical Society of Liverpool: *Proceedings.*
Liverpool Biological Society: *Proceedings.*
Liverpool Geological Society: *Proceedings.*
Marine Biological Association: *Journal.*
Marlborough College Natural History Society: *Reports.*
Mercantile Guardian, London.
Mineralogical Society: *Mineralogical Magazine.*
North of England Institute of Mining and Mechanical Engineers: *Transactions; Annual Report.*
Oxford University: *Calendar.*
Royal Anthropological Institute of Great Britain: *Journal.*

Royal Botanic Gardens, Edinburgh : *Notes.*
Royal Colonial Institute : *United Empire.*
Royal Geographical Society : *Geographical Journal.*
Royal Irish Academy : *Proceedings.*
Royal Philosophical Society of Glasgow : *Proceedings.*
Royal Physical Society of Edinburgh : *Proceedings.*
Royal Scottish Geographical Society : *Scottish Geographical Magazine.*
Royal Society, Dublin : *Economic Proceedings.*
Royal Society of Edinburgh : *Proceedings ; Transactions.*
Royal Society, London : *Proceedings* (Series A, B) ; *Phil. Trans.* (Series A, B) ; *Year-book.*
Royal Society of Literature : *Transactions.*
Royal Statistical Society, London : *Journal.*
Victoria Institute, London : *Journal of Transactions.*
Zoological Society of London : *Proceedings and Transactions.*

Austria.

Hofmuseum, Wien.
K.K. Central Anstalt für Meteorologie und Erdkunde, Vienna.
K.K. Geologischen Reichlanstalt, Vienna : *Verhandl ; Jahrb.*
K.K. Naturhistorischen Hofmuseums, Vienna : *Annalen.*
K.K. Zoologisch-Botanische Gesellschaft, Vienna : *Verhandl.*

Belgium.

Académie Royale de Belgique : *Bulletins.*
Librairie Nationale d'Art et d'Histoire : *Les Cahiers belges.*
Société Royale de Botanique de Belgique : *Bulletins.*
Société Royale Zoologique et Malacologique de Belgique : *Annales*
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